The Beauty and Benefits of Science theme highlights the “unreasonable effectiveness” of the scientific enterprise in creating economic growth, solving societal problems, and satisfying the essential human drive to understand the world in which we live.

Program Chair

William H. Press
AAAS President and Program Chair
Warren J. and Viola M. Raymer
Professor in Computer Science and Integrative Biology
University of Texas at Austin

Featured Plenary Speakers

Sherry Turkle
Massachusetts Institute of Technology
*The Robotic Moment: What Do We Forget When We Talk to Machines?*

Nathan Myhrvold
Intellectual Ventures
*Modernist Cuisine: The Art and Science of Cooking*

Cynthia Kenyon
University of California, San Francisco
*Mechanisms for Life Extension in C. elegans*

Robert Kirshner
Harvard University
*The Beauty of the Accelerating Universe*

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Transforming Undergraduate Education in STEM:
Building a Community to Transform Undergraduate STEM Education

2013 TUES Principal Investigators (PIs)
Conference

January 23-25, 2013
Renaissance Washington DC Hotel

Co-hosted by
American Association for the Advancement of Science (AAAS) Education and Human Resources Programs (EHR) and National Science Foundation (NSF) Division of Undergraduate Education (DUE)
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Overview of the Conference

The overall outcome of the conference is to provide NSF TUES Principal Investigators (PIs) and team leaders with an opportunity to: (a) learn about and share innovative ideas for transforming undergraduate STEM education; (b) implement innovative STEM undergraduate education ideas, as appropriate; (c) spread the use of innovative STEM undergraduate education ideas to their colleagues; and (d) make new connections and create collaborations.

To facilitate networking and interaction among faculty and educational leaders engaged in improving undergraduate STEM education, this conference features mostly poster sessions and small group discussions. The nearly 400 poster presentations are organized into 3 sessions by STEM disciplines. Since the theme of this conference is Building a Community to Transform Undergraduate STEM Education, as part of the abstract, poster presentations, discussions, and post-conference activities, TUES leaders are asked to reflect on the following:

- Intended project outcomes;
- Methods and strategies;
- Evaluation methods and results;
- Dissemination activities;
- Project impact;
- Challenges; and
- Key findings.

The conference small group discussion sessions led by TUES PIs are focused on:

- Dissemination and project management;
- Materials development;
- Pedagogy;
- Personnel development (faculty, post-docs, graduate student, etc.);
- Research and Assessment;
- Technology-based education; and
- Other topics, including community college partnerships.

The small group discussion sessions led by NSF TUES Program Directors are focused on:

- Dissemination strategies;
- Evaluation strategies;
- Other NSF funding opportunities;
- Preparing reports: present and future; and
- Project sustainability.

The TUES Conference was organized by staff of the NSF Division of Undergraduate Education and the AAAS Education and Human Resources Programs.
About the NSF TUES Program

The Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES) Program (formerly the Course, Curriculum and Laboratory Improvement – CCLI Program) seeks to improve the quality of science, technology, engineering, and mathematics (STEM) education for all undergraduate students. The vision of the program is excellent STEM education for all undergraduate students. The goals of the program reflect national concerns about producing skilled STEM professionals (including K-12 teachers), along with citizens that are knowledgeable about STEM and how it relates to their lives. The program strives to build on a community of faculty that is committed to improving undergraduate STEM education.

The TUES Program supports projects representing different phases of development, ranging from small exploratory investigations to large comprehensive projects. The program supports projects to:

- Create, adapt, and disseminate new learning materials, resources and teaching strategies to reflect advances both in STEM disciplines and in what is known about teaching and learning.
- Develop and implement transformative strategies, including faculty professional development, educational innovations, assessment of student learning, K-12 teacher preparation, evaluation of innovations, or research on STEM teaching and learning.
- Further the work of the program itself (e.g., synthesis and dissemination of findings across the program).

The TUES Program is part of the NSF Directorate for Education and Human Resources (EHR), Division of Undergraduate Education (DUE).

More information about the NSF TUES Program can be located on the website (http://nsf.gov/funding/pgm_summ.jsp?pims_id=5741&org=DUE&from=home).

About AAAS

The American Association for the Advancement of Science, (AAAS), is an international non-profit organization dedicated to advancing science around the world by serving as an educator, leader, spokesperson and professional association. In addition to organizing membership activities, AAAS publishes the journal Science, http://www.sciencemag.org/, as well as many scientific newsletters, books and reports, and spearheads programs that raise the bar of understanding for science worldwide.

AAAS was founded in 1848, and includes some 261 affiliated societies and academies of science, serving 10 million individuals. Science has the largest paid circulation of any peer-reviewed general science journal in the world, with an estimated total readership of one million. The non-profit AAAS is open to all and fulfills its mission to “advance science and serve society” through initiatives in science policy; international programs; science education; and more. For the latest research news, log onto EurekAlert!, http://www.eurekalert.org/, the premier science-news website, a service of AAAS.

Membership and Programs

Open to all, AAAS membership includes a subscription to Science. Four primary program areas fulfill the AAAS mission:

- Science and Policy
- International Activities
- Education and Human Resources
- Project 2061

AAAS Mission

AAAS seeks to "advance science, engineering, and innovation throughout the world for the benefit of all people." To fulfill this mission, the AAAS Board has set these broad goals:

- Enhance communication among scientists, engineers, and the public;
- Promote and defend the integrity of science and its use;
- Strengthen support for the science and technology enterprise;
- Provide a voice for science on societal issues;
- Promote the responsible use of science in public policy;
- Strengthen and diversify the science and technology workforce;
- Foster education in science and technology for everyone;
- Increase public engagement with science and technology; and
- Advance international cooperation in science.

Visit the AAAS website at http://www.aaas.org/.
January 23, 2013

Dear Participant,

On behalf of the Directorate for Education and Human Resources and the National Science Foundation, I want to welcome you to this Principal Investigator's conference for the Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) Program.

The TUES program is intended to foreground our interest in improving STEM learning through research and development efforts that bring about change in undergraduate education at a national level. It is our belief that EHR can produce a positive impact when we are able to close the loop between research and development; where research informs development and, in turn, development fosters future research. This on-going, cyclical process allows us to accumulate and build on knowledge, promising practices and resources to improve STEM learning. It is our goal to constantly extend knowledge about how students learn and foster the translation of that knowledge into effective teaching. Each of you is contributing substantially to this goal, and I thank you for your excellent work.

It has been rewarding and affirming to observe the growth in engagement with transformed and transforming teaching practice among undergraduate STEM faculty over the last decade. We look forward to hearing about and discussing your current work. I hope that each of you finds a receptive audience for your effort, while sharing your knowledge and learning from colleagues as well.

Sincerely,

Joan E. Ferrini-Mundy
Assistant Director
Directorate for Education and Human Resources
National Science Foundation

Telephone (703) 292-8600  FAX (703) 292-9179
January 23, 2013

Dear Participant,

On behalf of the National Science Foundation's Division of Undergraduate Education, I welcome you to this Principal Investigator’s conference for the Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) Program.

This is the second PI meeting since we renamed the program to reflect an interest in transforming undergraduate STEM education, an aim I know that you have all shared. You are the vanguard for changing the culture of undergraduate STEM education. Your efforts lead to changes in core practices so that they reflect what we understand about how students learn. You are leading an effort that encourages all faculty to view their teaching as they would scientific research, as a continuous opportunity to reflect upon and understand student learning more deeply.

We hope this meeting provides you affirmation for the importance of your work, and many opportunities to enhance it through connections with like-minded colleagues.

Sincerely,

Deborah F. Lockhart
Acting Division Director
Division of Undergraduate Education
National Science Foundation
January 23, 2013

Dear Colleagues:

On behalf of the American Association for the Advancement of Science and our Directorate for Education and Human Resources Programs, we want to join with NSF in welcoming you to this Principal Investigator’s conference for the Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) Program.

During the past couple of years more attention than ever has been given to strengthening undergraduate STEM education. Reports such as Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics, prepared by the President’s Council of Advisors on Science and Technology (PCAST) calls for adoption of empirically validated teaching practices and replacing standard laboratory courses with discovery-based research courses.

As more and more attention turns to the quality of STEM undergraduate education, TUES is vitally important to our nation. Many of the most fundamental challenges in human resources development rest on the shoulders of faculty and educators in colleges and universities and other organizations. These challenges include building a STEM savvy workforce for the 21st century; educating and inspiring the next generation of STEM teachers; and attracting a broad and diverse base of talent to consider and pursue education and careers in STEM related fields.

We commend TUES investigators for seeking to develop materials and teaching strategies and undertaking the research and development needed to understand what works for whom and sharing these findings with the community. As leaders in the STEM undergraduate education community, you are at the forefront of developing a globally competitive workforce and citizens who are aware of and engaged in STEM issues.

We hope this TUES conference provides you with new ideas and contacts as you continue your important work to strengthen STEM undergraduate education.

Sincerely,

Alan I. Leshner, Chief Executive Officer, AAAS and Executive Publisher, Science
Shirley M. Malcom, Director, AAAS Education and Human Resources (EHR) Programs
Yolanda S. George, Deputy Director and Program Director, EHR
**Conference Staff**

**NSF Directorate for Education and Human Resources**  
Joan E. Ferrini-Mundy, Assistant Director

**NSF Division of Undergraduate Education**  
Deborah F. Lockhart, Division Director (Acting), (703)292-4858, dlockhar@nsf.gov  
Katherine Jean Denniston, Deputy Director, (703)292-8496, kdennist@nsf.gov

**NSF TUES Program Directors**  
Don L. Millard, (703)292-4620, dmillard@nsf.gov  
Myles Boylan, (703)292-4617, mboylan@nsf.gov  
Susan Finger, (703)292-4639, sfinger@nsf.gov  
Terry Woodin, (703)292-4657, twoodin@nsf.gov

**BIOLOGICAL SCIENCES**  
V. Celeste Carter, (703)292-4651, vccarter@nsf.gov  
Kathleen Bergin, (703)292-5171, kbergin@nsf.gov  
William Grisham, (703)292-2260, wgrisham@nsf.gov  
Jose Herrera, (703)292-5128, jherrera@nsf.gov  
Joan Prival, (703)292-4635, jprival@nsf.gov  
Terry Woodin, (703)292-4657, twoodin@nsf.gov

**CHEMISTRY**  
David Brown, (703)292-8831, drbrown@nsf.gov  
Joseph Grabowski, (703)292-4653, jgrabows@nsf.gov  
Herbert Richtol, (703)292-4648, hrichtol@nsf.gov

**COMPUTER SCIENCE**  
Guy-Alain Amoussou, (703)292-8670, gamouso@nsf.gov  
Jane Prey, (703)292-4620, jprey@nsf.gov  
Victor Piotrowski, (703)292-5141, vpiotrow@nsf.gov  
Suzanne Westbook, (703)292-4640, swestbro@nsf.gov

**ENGINEERING**  
Maura Borrego, (703)292-7855, mborrego@nsf.gov  
Louis Everett, (703)292-4645, leverett@nsf.gov  
Susan Finger, (703)292-4639, sfinger@nsf.gov  
Don Millard, (703)292-4620, dmillard@nsf.gov  
John Yu, (703)292-4647, zyu@nsf.gov

**GEOLOGICAL SCIENCES**  
Peter Lea, (703)292-4643, plea@nsf.gov

**INTERDISCIPLINARY**  
Corby Hovis, (703)292-4625, chovis@nsf.gov  
Herbert Richtol, (703)292-4648, hrichtol@nsf.gov

**MATHEMATICS**  
Ron Buckmire, (703)292-5323, rbuckmir@nsf.gov  
Michael Jacobson, (703)292-4642, mjacobso@nsf.gov  
Lee Zia, (703)292-5140, lzia@nsf.gov

**PHYSICS / ASTRONOMY**  
Joyce Evans, (703)292-5098, jevans@nsf.gov  
Duncan McBride, (703)292-4630, dmcbride@nsf.gov  
Gary White, (703)292-4618, gwhite@nsf.gov

**RESEARCH / ASSESSMENT**  
Connie Della-Plana, (703)292-5309, cdellapi@nsf.gov

**SOCIAL SCIENCES**  
Myles Boylan, (703)292-4617, mboylan@nsf.gov

---

**AAAS Education and Human Resources**  
Shirley M. Malcom, Director  
Yolanda S. George, Deputy Director

**AAAS Conference Team**  
Donna Behar  
Gerard Boulin  
Betty Calinger  
Nicole Davies  
Cee Cee Fenwick  
Sabira Mohamed

**AAAS Office of Public Programs**  
Janel Kiley, Senior Art Associate

**Technology Team**  
Chrissy Rey-Drapeau, Pongo Interactive  
Kelly Hansen, Pongo Interactive  
Michael Dance, Pongo Interactive
Biographies

Bruce Alberts, Editor-in-Chief, Science, Professor of Biochemistry and Biophysics, University of California, San Francisco, and President Emeritus, U.S. National Academy of Sciences

Bruce Alberts, a prominent biochemist with a strong commitment to the improvement of science and mathematics education, serves as Editor-in-Chief of Science and as one of President Obama’s first three Science Envoys. Alberts is also Professor Emeritus in the Department of Biochemistry and Biophysics at the University of California, San Francisco, to which he returned after serving two six-year terms as the president of the National Academy of Sciences (NAS).

During his tenure at the NAS, Alberts was instrumental in developing the landmark National Science Education standards that have been implemented in school systems nationwide. The type of “science as inquiry” teaching we need, says Alberts, emphasizes “logical, hands-on problem solving, and it insists on having evidence for claims that can be confirmed by others. It requires work in cooperative groups, where those with different types of talents can discover them – developing self confidence and an ability to communicate effectively with others.” Alberts is also noted as one of the original authors of The Molecular Biology of the Cell, a preeminent textbook in the field now in its fifth edition. For the period 2000 to 2009, he served as the co-chair of the InterAcademy Council, a new organization in Amsterdam governed by the presidents of 15 national academies of sciences and established to provide scientific advice to the world.

Committed in his international work to the promotion of the “creativity, openness and tolerance that are inherent to science,” Alberts believes that “scientists all around the world must now band together to help create more rational, scientifically-based societies that find dogmatism intolerable.” Widely recognized for his work in the fields of biochemistry and molecular biology, Alberts has earned many honors and awards, including 16 honorary degrees. He currently serves on the advisory boards of more than 25 non-profit institutions, including the Gordon and Betty Moore Foundation.

Myles G. Boylan, Program Director, Division of Undergraduate Education (DUE), NSF

Myles G. Boylan currently serves as Program Director, Graduate Education Research, Division of Graduate Education and as a lead program director for the Transforming Undergraduate Education in STEM (TUES) program. His other program responsibilities include Ethics Education in Science and Engineering (ESEE); NSF Director’s Award for Distinguished Teaching Scholars (DTS); Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP).

He joined NSF in 1984, after holding academic appointments at the Ohio State University, Case Western Reserve University, and Colby College. While at Colby College he served as department chair. His academic research focused on the process and diffusion of technological innovation in private industry, particularly manufacturing. His instructional innovations included early advocacy and practice of small group learning.

While at NSF, Boylan has served in the Division of Policy Research and Analysis (which later became the Director’s Office of Planning and Assessment), and the Division of Undergraduate Education. He served as executive secretary of a National Science Board subcommittee that examined the condition of national literacy in science, technology, engineering, and mathematics (STEM) fields in the early 1990s; and as staff leader for a comprehensive study, released in 1996, on the state of undergraduate education in STEM disciplines.

Boylan has also served as an internal consultant to the NSF division concerned with data on the health of the national science and engineering enterprise, including the condition of science and engineering education. In addition to the programs for which he serves as a lead program director, Boylan has significantly participated in the operation and management of 5 other NSF grants programs. In 2003-04, he worked with the Center for the Advancement of Scholarship on Engineering Education (CASEE).

Boylan earned his bachelor’s degree in mathematics from Michigan State, his masters’ degree in organizational science from Case Institute of Technology, and his doctorate in industrial economics from Case Western Reserve University.

William David Burns, Executive Director, National Center for Science and Civic Engagement

William David Burns is the executive director of the National Center for Science and Civic Engagement, co-founder and principal investigator of SENCER - a National Science Foundation supported faculty empowerment and curricular reform program, publisher of Science Education and Civic Engagement - An International Journal, and professor of general studies at the Harrisburg University of Science and Technology.

Burns also serves as principal investigator (PI) of SENCER-ISE II, a new NSF-supported initiative to connect formal science education at the college level with informal science educators.
Biographies

Donna F. Edwards, U.S. House of Representatives, Maryland’s 4th Congressional District

Congresswoman Donna F. Edwards represents Maryland’s 4th Congressional District, comprising portions of Prince George’s and Montgomery Counties. She was sworn in, in a special election as a member of the U.S. House of Representatives in the 110th Congress in June 2008, and began her first full-term in the 111th Congress in 2009.

Congresswoman Edwards has enjoyed a diverse career as a nonprofit public interest advocate and in the private sector on NASA’s Spacelab project. In 1994, as co-founder and executive director of the National Network to End Domestic Violence, she led the effort to pass the Violence Against Women Act that was signed into law by President Clinton.

Since being sworn in, Congresswoman Edwards has secured a number of legislative accomplishments to improve the lives of working families in her Congressional District and around the country. Her first act as a Member of Congress was to add Maryland to the Afterschool Suppers Program, ensuring access to nutritional suppers to afterschool and youth development programs in schools located in low-income areas. During the health care debate, Congresswoman Edwards secured a provision that holds insurance companies accountable for unjustifiable rate increases.

Congresswoman Edwards has introduced legislation to expand research and development, domestic manufacturing, and infrastructure spending to create jobs and grow our economy. She was also the first Member of the House to introduce and champion a constitutional amendment to overturn the Supreme Court’s Citizens United decision.

In the 112th Congress, Congresswoman Edwards serves:

On the Transportation and Infrastructure Committee where she sits on:

- The Subcommittee on Highways and Transit
- The Subcommittee on Water Resources and Environment
- The Subcommittee on Economic Development, Public Buildings, and Emergency Management

On the Science and Technology Committee where she sits on:

- The Subcommittee on Technology and Innovation - Ranking Member
- The Subcommittee on Space and Aeronautics

On the House Committee on Standards of Official Conduct.

As a member of the Tom Lantos Human Rights Commission.

Representative Edwards completed undergraduate studies at Wake Forest University and received her Juris Doctor from the University of New Hampshire School of Law (formerly the Franklin Pierce Law Center). She is the proud mother of one son.
David Evans, Vice President for Education at Udacity and Professor of Computer Science, University of Virginia

David Evans is an Associate Professor in Computer Science at the University of Virginia where he leads research in computer security and privacy. He taught an introductory computer science course for Udacity which has enrolled over 240,000 students, as well as an applied cryptography course. He is the author of an open introductory computer science textbook (http://www.computingbook.org) and founding director of an Interdisciplinary Major in Computer Science.

Joan Ferrini-Mundy, Assistant Director, Directorate for Education and Human Resources, NSF

Joan Ferrini-Mundy is the Acting Assistant Director of the National Science Foundation (NSF) for Education and Human Resources (EHR). In 2009, she served as Acting Executive Officer for the EHR Directorate, and from January 2007 through December 2009 was Director of EHR’s Division of Research on Learning in Formal and Informal Settings (DRL).

While at NSF, Ferrini-Mundy continues to hold appointments at Michigan State University (MSU) as a University Distinguished Professor of Mathematics Education in the Departments of Mathematics and Teacher Education. She served as Associate Dean for Science and Mathematics Education in the College of Natural Science at MSU from 1999-2006.

Ferrini-Mundy was a Visiting Scientist in NSF’s Teacher Enhancement Program from 1989-1991, and served as Director of the Mathematical Sciences Education Board and Associate Executive Director of the Center for Science, Mathematics, and Engineering Education at the National Research Council from 1995-1999. She directed the Michigan Department of Education Teacher Preparation Policy Study Group (2006-2007) and chaired the MI Mathematics High School Content Expectations Development Committee.

From 1983-1999, Ferrini-Mundy was a member of the Mathematics Department at the University of New Hampshire, and in 1982-1983 she was a mathematics faculty member at Mount Holyoke College, where she co-founded the Summer-Math for Teachers Program. She has served on the Board of Directors of the National Council of Teachers of Mathematics (NCTM), chaired the Writing Group for NCTM’s 2000 Principles and Standards for School Mathematics, and served on the Board of Governors of the Mathematical Association of America.

In 2007-2008, representing NSF, she served as an ex officio member of the President’s National Mathematics Advisory Panel, and co-chaired the Instructional Practices Task Group. Ferrini-Mundy holds a PhD in mathematics education from the University of New Hampshire; her research interests include calculus teaching and learning, the development and assessment of teachers’ mathematical knowledge for teaching, and mathematics and science education policy.

Yolanda George, Deputy Director, Education and Human Resources (EHR) Programs, AAAS

Yolanda Scott George is Deputy Director and Program Director, Education and Human Resources Programs, American Association for the Advancement of Science (AAAS). She has served as Director of Development, Association of Science-Technology Centers (ASTC), Washington, DC; Director, Professional Development Program, University of California, Berkeley, CA; and as a research biologist at Lawrence Livermore Laboratory, Livermore, California involved in cancer research and cell cycle studies using flow cytometer and cell sorters.

George conducts evaluations, workshops and reviews for the National Institutes of Health and National Science Foundation, as well as for private foundation and public agencies, including the European Commission. She develops and coordinates conferences and workshops related to STEM undergraduate reform and recruitment and retention of minorities, women, and persons with disabilities in STEM. She works with UNIFEM, UNESCO, L’Oreal USA and Paris and non-governmental organizations on gender, science, and technology initiatives related to college and university recruitment and retention and women leadership in STEM.

She currently serves as principal investigator (PI) or co-PI on several National Science Foundation (NSF) grants, including Vision and Change in Undergraduate Biology Education; National Science Education Digital Library (NSDL) Biological Sciences Pathways; Historically Black Colleges and Universities-Undergraduate Programs (HBCU-UP); Robert Noyce Teacher Scholarship Program; Transforming Undergraduate Education in STEM (TUES) and Virtual Faculty Workshop; and Women’s International Research Collaborations at Minority Serving Institutions. In addition, George is the lead AAAS staff person for the L’Oreal USA Fellowships for Women in Science Program (postdoctoral fellowships) and the David and Lucile Packard Foundation HBCU Graduate Scholars Program (graduate school fellowships).
Biographies

George serves on a number of boards or committees, including: Maria Mitchell Women in Science Awards Committee; McNeil/Lehrer Productions Online Science Reports Advisory Committee; Burroughs Wellcome Fund, Science Enrichment Program Grants, Advisory Board; The HistoryMakers, ScienceMakers, Advisory Board; and the National Advisory Board of The American Physical Society Physics Bridge Program.

George has authored or co-authored over 50 papers, pamphlets, and hands-on science manuals. She received her B.S. and M.S. from Xavier University of Louisiana and Atlanta University in Georgia, respectively.

Nathan Klingbeil, Senior Associate Dean and Professor, Mechanical and Materials Engineering, Wright State University

Nathan Klingbeil is a Professor of Mechanical Engineering and Senior Associate Dean in the College of Engineering and Computer Science at Wright State University (Dayton, OH). He is the lead investigator for Wright State’s National Model for Engineering Mathematics Education, which is currently funded by both NSF CCLI Phase 3 and STEP Type 1 awards. Klingbeil held the University title of Robert J. Kegerreis Distinguished Professor of Teaching from 2005-2008, and served as the College’s Director of Student Retention and Success from 2007-2009. He has received numerous awards for his work in engineering education, and was named the 2005 Ohio Professor of the Year by the Carnegie Foundation for the Advancement of Teaching and Council for Advancement and Support of Education (CASE).

Alan I. Leshner, Chief Executive Officer, AAAS, and Executive Publisher, Science

Alan I. Leshner has been Chief Executive Officer of the American Association for the Advancement of Science and Executive Publisher of the journal Science since December 2001. AAAS (triple A-S) was founded in 1848 and is the world’s largest, multi-disciplinary scientific and engineering society.

Before coming to AAAS, Leshner was Director of the National Institute on Drug Abuse (NIDA) from 1994-2001. One of the scientific institutes of the U.S. National Institutes of Health, NIDA supports over 85% of the world’s research on the health aspects of drug abuse and addiction.

Before becoming Director of NIDA, Leshner had been the Deputy Director and Acting Director of the National Institute of Mental Health. He went to NIMH from the National Science Foundation (NSF), where he held a variety of senior positions, focusing on basic research in the biological, behavioral and social sciences, science policy and science education.

Leshner went to NSF after 10 years at Bucknell University, where he was Professor of Psychology. He has also held long-term appointments at the Postgraduate Medical School in Budapest, Hungary; at the Wisconsin Regional Primate Research Center; and as a Fulbright Scholar at the Weizmann Institute of Science in Israel. Dr. Leshner is the author of a textbook on the relationship between hormones and behavior, and has published over 150 papers for both the scientific and lay communities on the biology of behavior, science and technology policy, science education, and public engagement with science.

Deborah F. Lockhart, Division Director (Acting), DUE, NSF

Deborah F. Lockhart received her B.A. in Mathematics from New York University and her MS and PhD in Mathematics from Rensselaer Polytechnic Institute. From 1973-76 she was an instructor and assistant professor in the Department of Mathematics at SUNY, College of Geneseo, prior to her appointments (assistant professor, associate professor) in the Department of Mathematical Sciences at Michigan Technological University from 1976 to 1991. She joined the NSF’s Division of Mathematical Sciences (DMS) as a program director in the Special Projects Program in 1988. In 1991, she became a permanent member of the DMS staff and in 1993, she became a program director in the Applied Mathematics Program. She is currently chair of the NSF working group for the Mathematical Sciences Priority Area.

Her mathematical interests lie broadly across applied mathematics and more specifically in the application of partial
differential equations to solid mechanics. She also has a strong interest in science policy.

Shirley M. Malcom, Director, EHR Programs, AAAS

Shirley M. Malcom, Director for Education and Human Resources (EHR) Programs at AAAS, has served as a program officer in the NSF Science Education Directorate; an assistant professor of biology, University of North Carolina, Wilmington; and a high school science teacher. Malcom received her PhD in Ecology from The Pennsylvania State University; Master’s in Zoology from the University of California, Los Angeles; and Bachelor’s with distinction in Zoology from the University of Washington. In addition, she holds 16 honorary degrees.

Malcom serves on several boards, including the Heinz Endowments and Public Agenda. She serves as a trustee of Caltech and as a Regent of Morgan State University. In 2003, Malcom received the Public Welfare Medal of the National Academy of Science, the highest award granted by the Academy. She was a member of the National Science Board, the policymaking body of NSF, from 1994 to 1998, and of the President’s Committee of Advisers on Science and Technology from 1994 to 2001.

Cathryn A. Manduca, Director, Science Education Resource Center, Carleton College

Cathryn A. Manduca is director of the Science Education Resource Center (SERC) at Carleton College. SERC is engaged in a wide variety of professional development projects for undergraduate faculty that use workshops, virtual events, and community authored websites to facilitate sharing of teaching materials and expertise. In association with this work, SERC has developed tools and strategies for disseminating educational resources, and engages in evaluation and research projects, including research on faculty learning in professional development programs and its impact on teaching and student learning. As part of this work, Manduca directs InTeGrate, an NSF funded STEP Center improving geoscience literacy and preparing a workforce that can use geoscience to address the challenges faced by society. Manduca is also the Executive Director of the National Association of Geoscience Teachers (NAGT).

Established in 1937, NAGT works to foster improvement in the teaching of the earth sciences at all levels of formal and informal instruction, to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public. Manduca received her BA in Geology from Williams College and her PhD in Geology from the California Institute of Technology. She is a fellow of the AAAS, and has received the American Geophysical Union prize for excellence in geophysical education, and the SCIENCE prize for online resources in education.

Don L. Millard, Lead Program Director, TUES Program, DUE, NSF

Donald L. Millard is a Program Director in the Division of Undergraduate Education at the National Science Foundation (NSF). He is involved with the Advanced Technology Education (ATE) program, the Math and Science Partnership (MSP) program and leads the Transforming Undergraduate Education in STEM (TUES) program.

Prior to joining NSF, Millard was the Director of Engineering Education and the Academy of Electronic Media at Rensselaer Polytechnic Institute. During his many years at Rensselaer, he served as a faculty member of the Electrical, Computer, and Systems Department and directed a number of research centers, including the Center for Integrated Electronics. He is the founder of the Mobile Studio project, which enables students to learn and perform experiments that use an oscilloscope, function generator, digital control, and some form of power supply - at anytime, any place.

Millard holds a patent for the development of a laser-induced, plasma-based Non-Contact Electrical Pathway and has received such awards as the Premier Award for Excellence in Engineering Education Courseware and the Best Paper Award of the Institute of Electronics and Electrical Engineers (IEEE). Millard has been voted Professor of the Year on three occasions, selected as RHA Professor of the Month, and was chosen as the Eta Kappa Nu Outstanding Professor in 2009.

William Oakes, Associate Professor, School of Engineering Education and Director of Engineering Projects in Community Service (EPICS), Purdue University

William (Bill) Oakes is the Director of the EPICS Program at Purdue University and
one of the founding faculty members of the School of Engineering Education with courtesy appointments in Mechanical, Environmental and Ecological Engineering as well as Curriculum and Instruction in the College of Education. He is a registered professional engineer. He has been active in dissemination of service-learning at the university and K-12 level, conducting more than 60 faculty and teacher professional development workshops, publishing conference and journal articles and contributing to nine books including co-authoring the first text for engineering service-learning. He has received numerous awards for his efforts at Purdue including being elected as a fellow of the Teaching Academy and listed in the Book of Great Teachers.

Oakes was the first engineering faculty member to receive the national Campus Compact Thomas Ehrlich Faculty Award for Service-Learning. He was a co-recipient of the National Academy of Engineering’s Bernard Gordon Prize for Innovation in Engineering and Technology Education and the recipient of the National Society of Professional Engineers’ Educational Excellence Award. He is a fellow of the American Society for Engineering Education and the National Society of Professional Engineers.

Katherine Perkins, Associate Professor of Physics and Director of PhET Interactive Simulations Project and Science Education, University of Colorado Boulder

Kathy Perkins is Director of the PhET Interactive Simulations Project at University of Colorado Boulder (CU). She also directs CU’s Science Education Initiative and serves as a faculty member in Physics. She was trained as an experimental physicist and atmospheric scientist at Harvard University, and transitioned to physics education research in January 2003 as a post-doctoral researcher with Carl Wieman. Since then, her work in science education research has focused on advancing STEM education through several avenues, including work and research on pedagogically-effective design and use of interactive simulations, sustainable course reform, students’ beliefs about science, and institutional change.

Russell L. Pimmel, Professor Emeritus, University of Alabama

Russell L. Pimmel is an emeritus professor at the University of Alabama and a recently retired Program Director in the Division of Undergraduate Education at National Science Foundation. In addition, he has held faculty positions at Ohio State University, University of North Carolina at Chapel Hill, and University of Missouri at Columbia; he worked as an engineer at Emerson Electric, Battelle Northwest Laboratory, and McDonnell-Douglas. His research interests focus on collaborative learning and faculty development with a special interest in virtual approaches. His three degrees are in Electrical Engineering with a B.S. from St Louis University and a M.S. and a Ph.D. from Iowa State University.

Susan Rundell Singer, Laurence McKinley Gould Professor, Biology and Cognitive Science Departments, Carleton

Susan Rundell Singer, Laurence McKinley Gould Professor, in the Biology and Cognitive Science Departments at Carleton, pursues a career that integrates science and education. In addition to a PhD in biology from Rensselaer, she completed a teacher certification program in New York State.

A developmental biologist who also does research on learning in genomics, Singer is a AAAS fellow and received both the American Society of Plant Biology teaching award and Botanical Society of America Charles Bessey teaching award. She directed Carleton’s Perlman Center for Learning and Teaching, was an NSF program officer in Biology, and is a co-author of the Vision and Change in Undergraduate Biology report and an introductory biology text.

Singer serves on numerous boards, including the NSF EHR advisory committee, Biological Sciences Curriculum Study Board, and the Botanical Society board of directors; is a member-at-large for the AAAS Education Section; participates in the Minnesota Next Generation Science Standards team; and was a member of the National Academies’ Board on Science Education. She has participated in six National Academies studies, including chairing the committees that authored America’s Lab Report, Promising Practices in STEM Undergraduate Education and Discipline-based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering.

Pratibha Varma-Nelson, Professor of Chemistry and Executive Director of the Center for Teaching and Learning, Indiana University Purdue University Indianapolis

Pratibha Varma-Nelson is Professor of Chemistry and the Executive Director of the Center for Teaching and Learning (CTL) at Indiana University-Purdue University Indianapolis (IUPUI). She
received her BS in Chemistry with first class from the University of Pune, India, in 1970 and a PhD in 1978 from the University of Illinois in Chicago in Organic Chemistry. She was a faculty at Saint Xavier University, Chicago from 1979 to 2002, where she was promoted to Professor in 1992 and served as department co-chair. She moved to Northeastern Illinois University in 2002 as Professor and Chair of the Department of Chemistry, Earth Science and Physics.

From August 2006-2008, she was a Program Director at NSF in the Division of Undergraduate Education. Since 1995, Varma-Nelson has been involved in the development, implementation and dissemination of the Peer-Led Team Learning (PLTL) model of teaching. She was the co-recipient of the 2008 James Flack Norris award for her role in developing PLTL Workshop model for teaching chemistry courses. In 2011, she was awarded the Stanley C. Israel Award for Advancing Diversity in the Chemical Sciences sponsored by the Committee on Minority Affairs of the American Chemical Society.
Agenda

Wednesday, January 23, 2013

2:00 pm – 5:30 pm  
Registration and Poster Setup  
Grand Registration/Grand Ballroom

5:30 pm – 6:45 pm  
Opening Plenary Session 1  
Renaissance Ballroom

Welcome:  
Don L. Millard, Lead Program Director, NSF

AAAS Welcome and Panel Moderator  
Bruce Alberts, Editor-in-Chief, “Science,” Professor of Biochemistry and Biophysics. University of California, San Francisco (UCSF), and President Emeritus, U.S. National Academy of Sciences

Panel on Advances in Undergraduate STEM Education

Panelists:  
William David Burns, Executive Director, National Center for Science and Civic Engagement

Nathan Klingbeil, Senior Associate Dean and Professor, Mechanical and Materials Engineering, Wright State University

Cathy Manduca, Director, Science Education Resource Center, Carleton College

William Oakes, Associate Professor, School of Engineering Education and Director of Engineering Projects in Community Service (EPICS), Purdue University

Katherine Perkins, Associate Professor of Physics and Director of PhET Interactive Simulations Project and Science Education, University of Colorado Boulder

Pratibha Varma-Nelson, Professor of Chemistry and Executive Director of the Center for Teaching and Learning, Indiana University Purdue University Indianapolis

Special Announcement:  
The TUES PI Forum

Russell Pimmel, Professor Emeritus, University of Alabama

7:00 pm – 9:00 pm  
Reception and Poster Session 1  
Grand Ballroom/Foyer

Thursday, January 24, 2013

7:00 am – 8:00 am  
Registration  
Grand Registration

Poster Setup  
Grand Ballroom

8:00 am – 9:00 am  
Plenary Session 2  
Renaissance Ballroom

Welcome Remarks:  
Joan E. Ferrini-Mundy, Assistant Director, NSF Directorate for Education and Human Resources (EHR)

Alan I. Leshner, AAAS Chief Executive Officer and Executive Publisher, “Science”

The Honorable Donna Edwards, U.S. House of Representatives

9:00 am – 9:15 am  
Break

9:15 am – 10:30 am  
PI-Led Workshops - Session A  
Room Assignments TBA

A1 When is Sustainability Really Possible: A Discussion

A2 Propagating Educational Innovations to have an Impact on Faculty Practice

A3 Designing for Diversity

A4 Teaching Outside the Box

A5 Enabling Students to “Bite Into” Algebra and Newtonian Mechanics Using Elementary Programming

A6 How to Optimize Technological Efforts in the Classroom

A7 Working as a Team for STEM Education
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<tr>
<th>Time</th>
<th>Session</th>
<th>Topic and Description</th>
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<tr>
<td>10:30 am – 10:45 am</td>
<td>Break</td>
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<tr>
<td>10:45 am – 12:15 pm</td>
<td>Poster Session 2</td>
<td>Grand Ballroom</td>
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<td>12:15 pm – 2:00 pm</td>
<td>Plenary Session 3 – Working Lunch and Keynote</td>
<td>Moderator: Don L. Millard, Lead Program Director, NSF TUES</td>
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<td></td>
<td>Topic and Speaker:</td>
<td>“The Massive Open Online Course (MOOC) Movement”</td>
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<td>Steve Blank, Author and Entrepreneur</td>
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<td>Joan Boughman, Senior Vice-Chancellor for Academic Affairs, University System of Maryland</td>
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<td>David Evans, Vice President for Education at Udacity and Professor of Computer Science, University of Virginia</td>
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<td>1:45 pm – 2:00 pm</td>
<td>Break</td>
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<td>2:00 pm – 3:15 pm</td>
<td>PI-Led Workshops – Session B</td>
<td>Room Assignments TBA</td>
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<td>B1 Outreach and Dissemination in a Difficult Economy: Opportunities and Challenges</td>
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<td>B2 Conducting Faculty Workshops: Building Dissemination into your Curriculum Development Activity</td>
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<td>B3 Lowering Barriers to Achieve Adoption and Institutionalization</td>
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<td>B4 The Strengths of Seeing in Science: Incorporating Visualizations in STEM Learning</td>
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<td>B5 Applying Resources and Good Practices from the World of Informal Science Education in Undergraduate STEM Education</td>
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<td>B6 Developing First-year Students’ Critical Analytical Abilities, Attitudes, and Interest in Science Through Intensive Analysis of Scientific Literature from Journals, Newspapers and the Internet</td>
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<td>B7 Methods for Teaching the Scientific Process</td>
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<td>B9 Building and Evaluating a Community of Researchers</td>
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<td>B10 Developing Expertise in Teaching</td>
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<td>B11 Problem-Based and Collaborative Learning Efforts Incorporating Community Engagement: Implementation and Assessment Challenges and Strategies</td>
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<td>B12 Practical Evaluation for CCLI/TUES Programs</td>
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<td>B13 Facilitating Technology-Enhanced Collaborative Learning</td>
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<td>B15 Technology-based Laboratory Improvement</td>
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<td>B16 Improving the Success of Science Students Transitioning From a Two-Year to a Four-Year School</td>
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<td>B17 Supporting Community College Faculty across the STEM Disciplines</td>
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Conference Program

Agenda

3:30 pm – 5:00 pm  Poster Session 3  
Grand Ballroom

5:00 pm – 5:15 pm  Break

5:15 pm – 6:30 pm  PD-Led Workshops – Session A  
Topical Sessions  
Room Assignments TBA

- Dissemination/Diffusion Strategies
- Evaluation Strategies
- Other NSF Funding Opportunities
- Project Reporting (Present & Future)
- Project Sustainability

6:30 pm  Remove Posters  
Grand Ballroom

Friday, January 25, 2013

7:00 am – 8:00 am  Continental Breakfast and Networking Session  
Renaissance Ballroom

8:00 am – 9:15 am  PI-Led Workshops - Session C  
Room Assignments TBA

- C1 Principles of Multi-Agent Simulation and Individual-Based Modeling and the NetLogo Programming Language
- C2 Authentic Research Projects in the Teaching Lab: Inception, Implementation, and Assessment for Learning
- C3 Problem-Based and Collaborative Learning Efforts Incorporating Community Engagement: Implementation and Assessment Challenges and Strategies
- C4 Developing a TUES PI Forum
- C5 Linking Students to Researchers and Practitioners to Enhance Interdisciplinary Experiential Learning
- C6 Does the Design of the SUN Materials Enhance Learning about Biological Energy Transfer?

9:15 am – 9:30 pm  Break

9:30 am – 10:45 am  PD-Led Workshops – Session B  
STEM Disciplines  
Room Assignments TBA

- Biological Sciences
- Chemistry
- Computer Science
- Engineering
- Geological Sciences
- Interdisciplinary
- Mathematics
- Physics or Astronomy
- Research or Assessment of Research
- Social Sciences

10:45 am – 11:00 am  Break
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<th>Time</th>
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<td>11:00 am</td>
<td>Closing Plenary – Session 4</td>
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<td>Renaissance Ballroom</td>
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<td><strong>Moderator:</strong></td>
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<td>Myles G. Boylan, Program Director,</td>
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<td>Division of Undergraduate Education (DUE), NSF</td>
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<td>Susan R. Singer, Laurence McKinley Gould Professor, Biology and</td>
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<td>Cognitive Science Departments, Carleton College</td>
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<td>Shirley M. Malcom, Director, AAAS</td>
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**Workshop Abstracts**

**SESSION A: THURSDAY, JANUARY 24, 2013**

9:15AM – 10:30AM

**A1**

**Session Category:** Dissemination and Project Management  
**Session Title:** When is Sustainability Really Possible: A Discussion  
**Co-Facilitators:** Andrew A. Beveridge, Queens College and Graduate Center CUNY, NSF Project Award #0919993, andy@socialexplorer.com

**Session Description:** NSF now emphasizes the possibility of financial sustainability of their projects. Since NSF award criteria include many items that are in the public interest and many of the projects are novel and develop prototypes, what models of financial sustainability are possible? The presider and attendees will discuss these issues together.

**Discussion Questions:**  
1.) Should sustainability be expected from NSF projects that test a new approach or model for education?  
2.) What models of sustainable funding are there? Private sources? Institutional sources? Other grants? Partnerships?  
3.) What models have people tried?

**A2**

**Session Category:** Dissemination and Project Management  
**Session Title:** Propagating Educational Innovations to have an Impact on Faculty Practice  
**Co-Facilitators:** Charles Henderson, Western Michigan University, NSF Project Awards #0715698 and 1122446, charles.henderson@wmich.edu  
Renee Cole, University of Iowa, NSF Project Award #1236926, renee-cole@uiowa.edu

**Session Description:** Most TUES projects result in good ideas for improving undergraduate education. One challenge facing the TUES community is how to encourage and facilitate the use of these good ideas by faculty outside the original development team. As part of our TUES project, we have developed a rubric to help us describe and evaluate propagation strategies in TUES proposals. In this session we will present the rubric, discuss possible uses, and solicit feedback from the audience.

**Discussion Questions:**  
1.) What are important factors to consider when designing and implementing propagation strategies? (e.g., who is the target audience?, how large of a change is required from typical practice?; to what extent are differences in student populations or institutional contexts likely to influence success? how prescribed is the desired change?)  
2.) What are ways to begin propagation at the early stages of a TUES project?  
3.) What are implicit assumptions behind common propagation strategies? To what extent are these assumptions valid?

4.) What level of detail of a propagation strategy is appropriate for a TUES proposal?  
5.) How could the TUES solicitation, review process or other program components be changed in order to encourage PIs to propose stronger propagation strategies?

**A3**

**Session Category:** Materials Development  
**Session Title:** Designing for Diversity  
**Co-Facilitators:** Matthew L. Miller, South Dakota State University, NSF Project Award #1044419, Matt.Miller@sdstate.edu  
Andy Johnson, Black Hills State University, NSF Project Award #0942699, Andy.Johnson@bhsu.edu

**Session Description:** This discussion will explore shared examples and identify best practices for promoting diversity in STEM. Initial examples will include: 1) Creating group work combining first- and second-year students in chemistry and biochemistry to promote an inclusive environment, and 2) Using inquiry based materials for physics which utilize multiple experiences, modalities, and inclusive social situations. A discussion point is how cognition, a culturally and socially based activity, potentially impacts non-white or non-western student performance.

**Discussion Questions:**  
1.) How can group work be designed to engage students of diversity?  
2.) Are inquiry-based activities effective toward promotion of diverse inclusion?  
3.) How can cultural or social beliefs strengthen student interest in STEM concepts?  
4.) What are the best practices for promoting inclusion?  
5.) What are the characteristics of these best practices?

**A4**

**Session Category:** Materials Development  
**Session Title:** Teaching Outside the Box  
**Co-Facilitators:** Kauser Jahan, Rowan University, NSF Project Award #0737277, jahan@rowan.edu  
Ivona Bezakova, Rochester Institute of Technology, NSF Project Award #1044721, ib@cs.rit.edu  
Pete Nelson, Benedictine University, NSF Project Award #0836833, pete@circle4.com

**Session Description:** Three projects will be demonstrated during this interactive session. The first introduces science and engineering principles using a living system such as an aquarium. The second project is about teaching introductory computer science/programming by asking students to design and implement a player strategy for a board game (we use existing, well-tested board games). The third project introduces students to quantitative scientific modeling using the “Marble Game”. The marble game is a prototypical kinetic Monte Carlo simulation that provides a conceptual framework that spans the STEM disciplines.
Discussion Questions:
1.) How can you bring ideas from biology, physics and science into this topic?
2.) How can you introduce ethics and sustainability through these activities?
3.) Could a tournament-for-fun idea be applied to other STEM disciplines? Any concrete suggestions?
4.) When and how should quantitative modeling be introduced into the life sciences curriculum?
5.) When and how should computational modeling and simulation be introduced into the STEM curriculum?
6.) What opportunities does the new MCAT provide for reforming the quantitative life sciences curriculum?

A5
Session Category: Materials Development
Session Title: Enabling Students to "Bite Into" Algebra and Newtonian Mechanics using Elementary Programming
Co-Facilitators: Eric Freudenthal, UTEP, NSF Project Award #0717877, efreudenthal@utep.edu

Session Description: Rather than teaching programming as an end in itself, we provide students with a tiny taste of programming that facilitates their exploration of the mathematical concepts underlying algebra and Newtonian mechanics. Participants will experience and analyze a few activities that have engaged at-risk learners in otherwise unmodified college and high school STEM courses.

This year, ~750 9th grade Algebra 1 students in El Paso will learn programming in this manner on graphing calculators.

Discussion Questions:
1.) How to adequately prepare high school and college instructors to incorporate this instructional approach into their courses,
2.) How to properly measure the effectiveness of this instructional approach,
3.) Whether programming ought to be exploited as a common supporting pillar for mathematical exploration in schools, and
4.) How would introductory CS courses be different if all students were exposed to programming in this manner during 9th grade Algebra 1?

A6
Session Category: Pedagogy
Session Title: How to Optimize Technological Efforts in the Classroom
Co-Facilitators: Edward Berger, University of Virginia, edward.berger@virginia.edu, NSF Project Awards #0717820 and 1123037 Edgar Corpuz, University of Texas-Pan American, ecorpuz@utpa.edu, NSF Project Awards #1154508 and 1035467

Session Description: Technology interventions can be powerful tools to support student learning. But at what cost? How much effort must a faculty member invest in developing new expertise in technology-mediated learning? What are the trade-offs associated with implementing new technology-based teaching strategies? What is the smallest meaningful action an instructor can take in deploying technology in class? This workshop explores these questions and provides practical, research-based guidance to faculty members.

A7
Session Category: Pedagogy
Session Title: Working as a Team for STEM Education
Co-Facilitators: Tracy Knowles, Bluegrass Community and Technical College, NSF Project Award #0942089, tracy.knowles@kctcs.edu

Session Description: This session will address the use of faculty learning communities and student teams to promote improvements in undergraduate STEM teaching and learning with a focus on new and emerging technologies and teaching methods. We will discuss ways to engage faculty and/or students, and explore both face-to-face and virtual strategies currently employed to support these STEM communities.

Discussion Questions:
1.) How can faculty learning communities support or encourage STEM teaching excellence?
2.) How can technology support or facilitate student learning and communication?
3.) What strategies are being used to encourage faculty and students to participate in learning teams?
4.) How do we promote a culture of sharing and communal improvement in support of College teaching and learning?
Jill Singer, SUNY - Buffalo State, NSF Project Award #1134963, singerjk@buffalostate.edu

Session Description: While partnerships within and across disciplines can be very productive and rewarding, establishing and maintaining effective interactions among all members can pose a variety of challenges. This workshop will focus on various aspects of partnerships including: (a) establishing partnerships within and across disciplines; (b) delineating responsibilities and expectations among the partners; and (c) dealing with challenges that may arise as a result of differences in perspective. Come prepared to share your experiences and lessons learned.

Discussion Questions:
1.) How to identify potentials partners within your discipline,
2.) How to identify potential partners across disciplines,
3.) What are effective models and strategies for creating structures to facilitate productive partnerships?, and
4.) Strategies for overcoming challenges that may develop with partners

A9
Session Category: Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
Session Title: Oral Assessments: Improving Understanding, Grades and Retention
Co-Facilitators: Mary Nelson, George Mason University, NSF Project Award #0817417, mary.nelson@colorado.edu

Session Description: This session will examine the effectiveness of oral assessments, where students attend voluntary small group sessions led by a facilitator and are asked to articulate their thinking about mathematics. Students learn to negotiate meaning and make mathematical connections. Examining graphical representations and discussing the purpose and rationale for procedures helps students make sense of difficult concepts. Data show orals participants improve understanding, grades and retention. Orals have also been used successfully in other disciplines.

Discussion Questions:
1.) If orals are voluntary and only motivated students attend, how can we know they wouldn’t have done better than the others without orals?
2.) How can we get faculty to agree to facilitate orals?
3.) Are students embarrassed if they can’t answer many of the questions?

A10
Session Category: Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
Session Title: Promoting Student Argumentation in STEM
Co-Facilitators: Renee Cole, University of Iowa, NSF Project Award #0816792, renee-cole@uiowa.edu

Marcy Towns, Purdue University, NSF Project Award #0817467, mtowns@purdue.edu

Session Description: The importance of incorporating more formal scientific argumentation into the STEM curriculum has been highlighted by several researchers in recent years, although not much work has been done in the undergraduate curriculum. As part of our TUES project, we used Toulmin analysis to document student reasoning in a physical chemistry class. In this session we will discuss how to promote student use of evidence-based reasoning in which students propose, defend, and critique scientific arguments.

Discussion Questions:
1.) How should formal scientific argumentation be introduced into STEM curricula?
2.) How can argumentation be facilitated in large, introductory courses?
3.) How can we provide feedback to students on the quality of their arguments?
4.) How do we best promote a culture of evidence-based reasoning?

A11
Session Category: Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
Session Title: Assessment of the Impact of Curricular/ Pedagogical Innovations on Student Learning – Concept Inventories and Beyond
Co-Facilitators: Maria Terrell, Cornell University, NSF Project Award #0837757, mst1@cornell.edu
Teri Reed-Rhoads, Texas A&M University, NSF Project Award #0920589, trhoads@purdue.edu
Lisa Schneider-Bentley, Cornell University, NSF Project Award #0837757, lms3@cornell.edu

Session Description: Assessment of the impact of curricular/ pedagogical innovations on student learning has benefited from the use of concept inventories. The work of ciHUB.org supports a community for concept inventory developers, researchers, and faculty, offering opportunities to share recent research on faculty development and adoption of innovations assessed by concept inventories. The development of the Mathematics Applications Inventory, designed to assess changes in students’ ability to apply mathematics to problems in physical science settings, will be highlighted.

Discussion Questions:
1.) What is the current state of concept inventory development in STEM disciplines?
2.) How are existing concept inventories being used in STEM disciplines?
3.) What is missing from the portfolio of inventories?
A12
Session Category: Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
Session Title: Evaluation and Assessment in a TUES Project: Suggestions, Observations, and Lessons Learned
Co-Facilitators: Mary Anne Sydlik, Western Michigan University, NSF Project Award #1022747, mary.sydlik@wmich.edu
Roberta Spalter-Roth, American Sociological Association, NSF Project Award #0837121, spalter-roth@asasnet.org
Mark-Urban-Lurain, Michigan State University, NSF Project Award #1022653, urban@msu.edu

Session Description: PIs are often confused about the role of external evaluation and assessment in NSF TUES grants. Workshop leaders will discuss: project evaluation tasks (data collection, formative and summative reports); the experience of having an “outsider” observing activities, collecting data, and giving feedback; and concrete suggestions for how to use unobtrusive data rather than low response-rate surveys or unrepresentative qualitative studies in a quasi-experimental design. We also will open the floor for comments/questions/sharing from participants.

Discussion Questions:
1.) How does evaluation work in the context of a CCLI/TUES project?
2.) What experiences have you had, either as an evaluator or PI/Co-PI, with assessment and evaluation?
3.) What are some types of data that are useful to collection, particularly in the context of a quasi-experimental design?
4.) What is the difference between data collected for research and data collected for evaluation?

A13
Session Category: Technology-Based Education
Session Title: Incorporation of Computer-Based Tools to Engage Students in STEM
Co-Facilitators: Robert B. Teese, Rochester Institute of Technology, NSF Project Award #1122828, rbtees@rit.edu
Priscilla Laws, Dickinson College, NSF Project Award #1123118, lawsp@dickinson.edu

Session Description: The LivePhoto Physics Group has been creating and testing a series of short single-topic interactive video expositions designed for introductory physics students. These Vignettes are designed to enable students to master concepts while learning basic data collection and analysis techniques. Vignettes can be made in any STEM discipline. In this workshop, we will help participants access and use a vignette. We will then explain how data about their interactions with the vignette are being collected in the background. This will segue into a discussion of how new technological tools can be used to understand preconceptions and gauge how different students acquire conceptual, mathematical, and epistemological knowledge.

A14
Session Category: Other
Session Title: Cultivating Relationships Between 2 and 4 Year Colleges
Co-Facilitators: Nikos Kiritis, McNeese State University, NSF Project Award #0942227, nikosk@mcneese.edu
Jan Hodder, University of Oregon, NSF Project Award #1122640, jhodder@uoregon.edu

Session Description: As tuition and fees in 4-year colleges rise, an increasing number of students seek to start their baccalaureate education at 2-year colleges. As a result, 2- and 4-year colleges need to collaborate more than ever in order to prepare students for the transition from one institution to the other. This workshop seeks to bring together educators from both types of institutions to talk about their experiences in promoting 2-year college student success. Although a number of issues will be introduced in order to start the discussion, this workshop will open the floor to its participants to share best and worst practices, success stories, etc.

Discussion Questions:
1.) Do you have a success story of a 2- and 4-year college collaboration to share with the group?
2.) What are some of the challenges 2-year students face during the transfer process to a 4-year college as well as right after they set foot on the 4-year campus and start classes?
3.) What is the biggest obstacle to a successful 2- and 4-year college collaboration?
4.) How can 2-year college students be better prepared for the transition to a 4-year college?

SESSION B: THURSDAY, JANUARY 24, 2013
2:00PM – 3:15PM

B1
Session Category: Dissemination and Project Management
Session Title: Outreach and Dissemination in a Difficult Economy: Opportunities and Challenges
Co-Facilitators: Enid Sichel, Five Colleges, Inc., NSF Project Award #1143659, enid_sichel@verizon.net

Session Description: This will be a brainstorming workshop on
outreach and dissemination in a difficult economy. Has the recession helped or hindered your outreach activities? Is it easier or harder to interest other people in your project results? Where are the opportunities or barriers to disseminating your project results? Does your scope include community colleges, large universities, private and public four-year colleges?

Discussion Questions:  
1.) How can you provide incentives for professors at other colleges to participate in your project?  
2.) How can you develop assessment tools without a full-time expert in assessment?  
3.) What technologies can you use to communicate with distant participants?  
4.) What are typical project glitches, and how can you develop a Plan B?

B2  
**Session Category:** Dissemination and Project Management  
**Session Title:** Conducting Faculty Workshops: Building Dissemination into Your Curriculum Development Activity  
**Co-Facilitators:** Nancy Baxter Hastings, Dickinson College, NSF Project Award # 0817071, baxter@dickinson.edu  
David M. Collard, Georgia Institute of Technology, NSF Project Awards # 1022796 and 1044034, david.collard@chemistry.gatech.edu

**Session Description:** This workshop will focus on strategies to offer effective workshops that inspire and equip faculty participants in curriculum development and reform. The session will address ways to: provide a sustained faculty development experience, offer a high quality workshop that meets participants’ expectations, and use technology as a mechanism for both content delivery and communication among workshop directors and participants. The workshop will be of particular interest to TUES/CCLI Type 1 and 2 proposers and awardees.

Discussion Questions:  
1.) What pedagogies work best in a faculty workshop setting?  
2.) Why consider adding a workshop to a TUES Type 1 or 2 proposal? Is this really feasible?  
3.) Where can I get help in planning a workshop? Are there successful models that I can adopt?  
4.) How do I effectively plan; advertise; collect and review applications; evaluate the activity; budget; and house and feed participants?  
4.) How can I provide a sustained faculty development experience?

B3  
**Session Category:** Dissemination and Project Management  
**Session Title:** Lowering Barriers to Achieve Adoption and Institutionalization  

Co-Facilitators: Katherine Perkins, University of Colorado Boulder, NSF Project Award #1226321, Katherine.Perkins@colorado.edu  
Melissa Dancy, University of Colorado Boulder, NSF Project Award #1223405, Melissa.Dancy@colorado.edu

**Session Description:** In this session, we will discuss the emerging research around faculty adoption, faculty adaptation, and institutionalization of TUES-developed educational practices, technology, or curricular resources. Participants will reflect on these findings to consider how initial project design/development choices and structures could support or hinder faculty adoption. Participants will also share how the objective of widespread adoption influences their dissemination strategies, and will discuss ongoing challenges in realizing widespread adoption.

Discussion Questions:  
1.) What are common factors influencing faculty adoption and institutionalization?  
2.) How do our initial project design and development choices support or hinder the goals of faculty adoption and institutionalization?  
3.) How can we structure successful dissemination and adoption support strategies?

B4  
**Session Category:** Materials Development  
**Session Title:** The Strengths of Seeing in Science: Incorporating Visualizations in STEM Learning  
**Co-Facilitators:** Tamar L. Goulet, University of Mississippi, NSF Project Award # 0942290, tlgoulet@olemiss.edu  
Aaron Striegel, University of Notre Dame, NSF Project Award #0942067, striegel@nd.edu

**Session Description:** For many STEM topics, visualizations can dramatically advance student learning by succinctly conveying and relying feedback on difficult concepts. This session will cover applications of computer-generated visualizations in Biology and Computer Science. In Biology, students actively contribute to the advancement of a topic, and its relevancy to their lives, by producing data visualizations in class. In Computer Science, motion is coupled with a visual interface to teach and offer feedback on computational thinking.

Discussion Questions:  
1.) Think of ways in which your students could collect and report data that would advance the course content.  
2.) Do your students see the relevance of the course content to their lives?  
3.) What is the most creative visualization that you have used in class?  
4.) Have you used visualizations from other course materials online?
B5
Session Category: Materials Development
Session Title: Applying Resources and Good Practices from the World of Informal Science Education in Undergraduate STEM Education
Co-Facilitators: Darrell Porcello, University of California, Berkeley’s Lawrence Hall of Science, NSF Project Award #1044441, porcello@berkeley.edu
Rashmi Nanjundaswamy, University of California, Berkeley’s Lawrence Hall of Science, NSF Project Award #1044441, rashmin@berkeley.edu
Ardice Harty, University of California, Berkeley’s Lawrence Hall of Science, NSF Project Award #1044441, hartry@berkeley.edu

Session Description: Join us for a discussion of how educators working in community colleges can tap into the resources and strategies used in science museums, afterschool programs, and other informal science education (ISE) venues. Presenters will step through the methods and results from an ongoing TUES I project using hands-on, inquiry-based nano and green technology activities in community college STEM courses. Participants will also learn about popular digital platforms from NSF (Howtomsmile.org, InformalCommons.org) and NASA (NASAwavelength.org) that showcase educational materials and projects from ISE professionals. The workshop will finish with a Q&A from participants with a history of partnering with local ISE institutions.

Discussion Questions:
1.) What online resources exist from the world of informal science education?
2.) How can community colleges partner with science museums and other informal science education organizations?
3.) What lessons from informal science educators can be applied to STEM higher education?

B6
Session Category: Pedagogy
Session Title: Developing First-year Students’ Critical Analytical Abilities, Attitudes, and Interest in Science through Intensive Analysis of Scientific Literature from Journals, Newspapers and the Internet
Co-Facilitators: Sally G. Hoskins, City College of New York, NSF Project Award #0942790, shoskins@ccny.cuny.edu
Kristy Kenyon, Hobart and William Smith College, NSF Project Award #1021443, kenyon@hws.edu

Session Description: Participants will experience an interactive C.R.E.A.T.E. (Consider, Read, Elucidate Hypotheses, Analyze data, Think of the next Experiment) classroom, gaining a student’s perspective on (a) use of novel tools for close reading/analysis and thoughtful data critique, (b) the power of designing/evaluating follow-up studies, and c) the critical insights into the nature of science gained through email connections with authors. We will also discuss assessment of multiple cognitive, metacognitive and attitudinal gains achieved with this teaching strategy.

Discussion Questions:
1.) How does CREATE align with recent research in teaching and learning?
2.) How to shift students’ approaches to their own learning.
3.) Why should I change my teaching style?
4.) Is it depth or breadth that should be achieved in a science course?

B7
Session Category: Pedagogy
Session Title: Methods for Teaching the Scientific Process
Co-Facilitators: Travis Rector, University of Alaska Anchorage, NSF Project Award #0920293, rector@uaa.alaska.edu

Session Description: Most instructors consider learning the process of scientific discovery to be a priority. Yet most classes focus only on mastering scientific content, which is only the outcome of scientific discovery. This workshop will discuss what methods can be used to teach this process, especially in introductory science classes.

Discussion Questions:
1.) What do we mean by the ‘process of scientific inquiry’?
2.) What are common student misconceptions about it?
3.) What in-class activities can be done to teach this process?
4.) What out-of-class (or lab) activities can be done?
5.) What are realistic instructor outcomes?

B8
Session Category: Pedagogy
Session Title: Improving Discipline-Specific Skills
Co-Facilitators: Judith E. Sims-Knight, University of Massachusetts Dartmouth, NSF Project Award #0941233, jsimsknight@umassd.edu

Session Description: Research on expertise shows that no matter how talented, intelligent, or creative people are, they must engage in years of deliberate and reflective practice to reach mastery in their discipline. The facilitator will first present some ways to allow students to engage in such deliberate practice. Then small groups with similar interests will explore ways of increasing such opportunities in their disciplines. Lastly we will reconvene as a group to discuss the groups’ conclusions.

Discussion Questions:
1.) What are the core skills of our disciplines, ones that respected experts have?
2.) How can we provide opportunities for students to practice these skills?
3.) How can we increase opportunities for students to practice without increasing the instructors’ grading responsibilities?
**4.) How can we help students to develop metacognitive skills, such as use of design process knowledge, so that they can continue to increase expertise both before and after they graduate?**

**B9**
**Session Category:** Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
**Session Title:** Building and Evaluating a Community of Researchers
**Co-Facilitators:** Sarah Miller, University of Wisconsin-Madison, NSF Project Award #0817545, smiller8@wisc.edu
Dedra Demaree, Oregon State University, demareed@physics.oregonstate.edu

**Session Description:** The term “community of researchers” has become an important goal in many of our projects and is often an outcome for which we are accountable. How do we define it? Accomplish it? Evaluate it? In this facilitated roundtable discussion, we will address issues related to forming and evaluating a community of researchers, including recommended considerations, strategies for success, and tips for evaluation. Participants should bring their questions, issues, and examples of success (and failure!).

**Discussion Questions:**
1.) What can be accomplished with a 'community of researchers' that otherwise can’t?
2.) What are the important issues to consider related to building a community of researchers? Across what boundaries (disciplines? campuses? institutional types?)?
3.) What are some barriers for each issue? Strategies for success?
4.) Participants share examples: What did the community value about the project and community? How did they come to value this? Did they develop a shared language? How did the development of the language provide evidence of shifts or expansions in the community members’ thinking? Did the project shift based on needs of the community?
5.) How can we evaluate the impact of such a community? For example, do you measure the impact on the community members, or the impact they have on the ‘problem’ at hand? What other stakeholders or impacts need to be considered?

**B10**
**Session Category:** Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
**Session Title:** Developing Expertise in Teaching
**Co-Facilitators:** Gili Marbach-Ad, University of Maryland, NSF Project Award # 0942020, gilim@umd.edu
Kaci Thompson, University of Maryland, NSF Project Award #0942020, kaci@umd.edu
Linda Barrington, University of Massachusetts Lowell, NSF Project Award #0942020, Linda_Barrington@uml.edu

**Session Description:** There is widespread agreement that evidence-based, student centered teaching approaches are more effective than traditional, teacher-centered approaches, but there exists a gap between instructor beliefs and practices. This workshop focuses on strategies to help instructors gain the knowledge and confidence they need to teach more effectively. It is intended for both individuals wanting to find effective strategies for improving their teaching and for those who are involved in organizing faculty professional development activities.

**Discussion Questions:**
1.) What are the hallmark of effective scientific teaching approaches?
2.) What are the challenges in moving to more effective teaching?
3.) What are examples for successful implementation of effective teaching strategies; and successful programs for faculty development?
4.) Write down one teaching strategy you are planning to adopt in your institution.

**B11**
**Session Category:** Pedagogy
**Session Title:** Problem-Based and Collaborative Learning Efforts Incorporating Community Engagement: Implementation and Assessment Challenges and Strategies
**Co-Facilitators:** Christopher Swan, Tufts University, NSF Project Award #1022927, chris.swan@tufts.edu
Olga Pierrakos, James Madison University, NSF Project Award #0837465, pierraox@jmu.edu
Jianyu Dong, California State University-Los Angeles, NSF Project Award #0737130, jdong2@calstatela.edu

**Session Description:** Problem-based learning (PBL) and collaborative learning (CL) approaches, applied using service-oriented projects, has recently received significant attention in engineering education. Successfully implementing and assessing such efforts, both for impacts to students and involved faculty, requires extensive pre-effort design and post-effort evaluation and analyses. This workshop focuses on the potential benefits and challenges of incorporating service-oriented PBL/CL in engineering. Specific examples will present design, management, and assessment strategies used in developing such efforts.

**Discussion Questions:**
1.) What are the different models of service-oriented PBL and CL used in engineering education?
2.) What are benefits and challenges of implementing PBL/CL in engineering education?
3.) What design, management, and assessment strategies can be used to measure impacts to student (e.g., learning) and faculty (e.g., development)?
**B12**

**Session Category:** Research and Assessment  
**Session Title:** Practical Evaluation for CCLI/TUES Programs  
**Co-Facilitators:** William Oakes, Purdue University, NSF Project Award #1123323, oakes@purdue.edu  
Ben Surpless, Trinity University, NSF Project Award #0942940, bsurples@trinity.edu

**Session Description:** Assessment of student learning, teaching methods, and curriculum has become increasingly important in college education. When designing an evaluation plan for NSF-funded programs, PIs must weigh assessment tool efficacy, practical implementation concerns, and the transferability of evaluation results to other programs and institutions. We will discuss the range of assessment tools that are available and the roles of formative and summative evaluation within the framework of an active NSF project.

**Discussion Questions:**  
1.) What assessment tools have you found most effective, not only in evaluation of NSF projects, but in your classes and at your institution?  
2.) How have you used formative evaluation to successfully improve/modify an NSF-funded program?  
3.) How have you or others at your institution used summative evaluation results to make improvements to existing programs or grant programs that followed?  
4.) Do you have an evaluation model that has worked well for your NSF project? If so, do you think your model is easily transferable to other institutions?  
5.) Have you considered disseminating the assessment results of your NSF project? If so, what do you consider the most effective way to spread the word?

**B13**

**Session Category:** Technology-Based Education  
**Session Title:** Facilitating Technology-Enhanced Collaborative Learning  
**Co-Facilitators:** Herman Gordon, University of Arizona, NSF Award #0942277, flash@arizona.edu  
Margot Vigeant, Bucknell University, mvigeant@bucknell.edu

**Session Description:** After students have worked together online, what is left to do face to face? A lot, as it turns out. Technology is only part of the equation; it helps us get students to grapple with more sophisticated questions about concepts and problem solving. But what do we do, as teachers, to facilitate learning? This workshop will focus on taking that next step, with examples from two different technology-enhanced collaborative learning environments.

**Discussion Questions:**  
1.) What are possible models for the hybrid classroom?  
2.) How do you choose a particular model?  
3.) How do you assess the learning experience in a hybrid model?

**B14**

**Session Category:** Technology-Based Education  
**Session Title:** Keeping Up With New Technology and "The Cloud"  
**Co-Facilitators:** Douglas B. Meade, University of South Carolina, NSF Project Award #1123170 , meade@math.sc.edu

**Session Description:** New technologies present new opportunities that can advance a project but keeping up with the latest technology can also consume time and effort without any real benefit.

Participants in this workshop will be asked to share their thoughts and experiences learning about and working with new technologies, including software and hardware. For example: How quickly will you start to make use of Windows 8 or Mac OS 10.8 (Mt. Lion)? Will you adapt your software to take advantage of multitouch and gesture-based interaction? How are you taking advantage of "the cloud"?

**Discussion Questions:**  
1.) How do you learn about new hardware/software?  
2.) What information sources are reliable/unreliable?  
3.) How quickly do you adopt new hardware/software?  
4.) What are your expectations regarding public domain and commercial software products?  
5.) Are you making use of "the cloud"?  
6.) If so, how? If not, why not? What additional developments would you need to see before you would consider using "the cloud"?  
7.) Are you making use of multitouch and gesture based interfaces? If not now, when?

**B15**

**Session Category:** Technology-Based Education  
**Session Title:** Technology-based Laboratory Improvement  
**Co-Facilitators:** Chengcheng Li, East Carolina University, NSF Project Award #0837722, liche@ecu.edu  
James B. Dabney, University of Houston - Clear Lake, NSF Project Award #0942552, dabney@uhcl.edu

**Session Description:** This session will bring together faculty interested in innovative technology-based laboratories. Technology-based labs provide many opportunities to foster learning by allowing students to work remotely with high-value equipment and to allow rapid reconfiguration to reduce the time overhead. These advantages bring challenges, such as teaching assistant (TA) and help desk support and training, dealing with rapid changes in technology, and equipment maintenance. Participants will discuss these and other relevant challenges, solutions, and open questions.

**Discussion Questions:**  
1.) How do you handle technology evolution in the technology-based lab?
Workshop Abstracts

2.) How do you handle TA and help desk training?
3.) What are your experiences using help desk and equipment support?
4.) How do you foster collaboration and teamwork via remote lab?
5.) How do you set up real-time and hands-on instruction via remote lab?
6.) How to reduce the lab cost?

B16
Session Category: Other
Session Title: Improving the Success of Science Students Transitioning From a Two-Year to a Four-Year School
Co-Facilitators: Harry Ungar, Cabrillo College, NSF Project Award #0737166, haungar@cruizio.com

Session Description: Academic institutions are now being asked to make student transfer more effective and efficient process. We will focus on opportunities and strategies that increase the roles that science faculty can play in improving student transfer.

Faculty can become agents who smooth the confusion and complexity of transfer and improve success rates for transfer students. Building strong connections and collaborations between the faculties of community colleges and baccalaureate-granting institutions is central to improving the transfer process.

Discussion Questions:
1.) Do you think the following approaches are appropriate and likely to be useful?
   a.) Enhancing Academic Support for Transfer Students
   b.) Developing a Sense of Belonging to a Community of Learners
   c.) Mentoring Transfer Students
2.) Are you familiar with other initiatives that have been successful in improving transfer?
3.) Will the methods that we use to improve student transfer in one field work in other areas; e.g., Biology vs Engineering?

B17
Session Category: Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
Session Title: Supporting Community College Faculty across the STEM Disciplines
Co-Facilitators: Mark Maier, Glendale Community College, NSF Project Award #1238279, mmaier@glendale.edu
Katherine Rowell, Sinclair Community College, NSF Project Award #1238279, katherine.rowell@sinclair.edu
Heather Macdonald, College of William & Mary, NSF Project Award #1238279, rhmacd@wm.edu

Session Description: This session will explore strategies to increase the use of existing discipline-specific resources by community college faculty. What are professional organizations and national projects across the STEM disciplines doing to support instruction in community colleges? What are models for discipline-specific professional development at professional meetings and on campus? Following a brief introduction, this workshop will provide opportunities for participants to discuss these issues with colleagues, sharing successes and challenges.

Discussion Questions:
1.) How do professional organizations in various disciplines reach out to community college faculty?
2.) What can we increase the involvement of community college faculty in professional organizations, both at professional meetings and in using the print and online resources of the professional organizations?
3.) What are some models for discipline-specific professional development on campus using resources of national NSF-funded programs as well as resources of professional organizations?
4.) What are effective strategies to engage colleagues, including adjuncts, in campus-based professional development using these resources?

SESSION C: FRIDAY, JANUARY 25, 2013
8:00AM – 9:15AM

C1
Session Category: Dissemination and Project Management
Session Title: Principles of Multi-Agent Simulation and Individual-Based Modeling and the NetLogo Programming Language
Co-Facilitators: Matthew Dickerson, Middlebury College, NSF Project Award #1044806, dickerso@middlebury.edu

Session Description: The first two-thirds of this workshop will be devoted to introducing the principles of multi-agent simulation and individual-based modeling, with examples from life and social sciences. Following this introduction, we will look at the NetLogo programming language for designing multi-agent simulation and explore it as both a research tool and an curricular tool (educational language). Participants will be invited to work with the language.

Discussion Questions:
1.) How and why might (or might not) this approach and language fit into an undergraduate computer science curriculum?
2.) What is the need for computational thinking in biological and social sciences?
3.) How does multi-agent simulation and individual-based modeling fit into your own discipline(s)?

C2
Session Category: Materials Development
Session Title: Authentic Research Projects in the Teaching Lab:
Inception, Implementation, and Assessment for Learning

Co-Facilitators: Steve Cessna, Eastern Mennonite University, NSF Project Award #0837578, cessnas@emu.edu
Tara Kishbaugh, Eastern Mennonite University, tara.kishbaugh@emu.edu

Session Description: We will discuss our experiences doing research projects in traditional undergraduate laboratory courses; we invite discussion on this topic from participant experiences. Common obstacles include project inception (what research projects can we manage, and what do we want them to learn from the experience?), project implementation (how will lab resources be managed?), and assessment and program evaluation (how will we grade all those complex assignments, and how will we know if we are affecting learning?)

Discussion Questions:
1.) What do we want undergraduate students to learn from their laboratory courses?
2.) Is the broadening of undergraduate research opportunities a goal of your department?
3.) What obstacles do you foresee, or have your experienced, when trying to implement in-class research experiences?
4.) Would students be more (or less) likely to learn those things if they were engaging in authentic research?
5.) How would we know that they've learned what we want them to?

C3
Session Category: Pedagogy
Session Title: Problem-Based and Collaborative Learning Efforts Incorporating Community Engagement – Implementation and Assessment Challenges and Strategies
Co-Facilitators: Christopher Swan, Tufts University, NSF Project Award #1022927, chris.swan@tufts.edu
Olga Pierrakos, James Madison University, NSF Project Award #0837465, pierraox@jmu.edu
Jianyu Dong, California State University-Los Angeles, NSF Project Award #0737130, jdong2@calstatela.edu

Session Description: Problem-based learning (PBL) and collaborative learning (CL) approaches, applied using service-oriented projects, has recently received significant attention in engineering education. Successfully implementing and assessing such efforts, both for impacts to students and involved faculty, requires extensive pre-effort design and post-effort evaluation and analyses. This workshop focuses on the potential benefits and challenges of incorporating service-oriented PBL/CL in engineering. Specific examples will present design, management, and assessment strategies used in developing such efforts.

Discussion Questions:
1.) What are the different models of service-oriented PBL and CL used in engineering education?
2.) What are benefits and challenges of implementing PBL/CL in engineering education?
3.) What design, management, and assessment strategies can be used to measure impacts to student (e.g., learning) and faculty (e.g., development)?

C4
Session Category: Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
Session Title: Developing a TUES PI Forum
Co-Facilitators: Yolanda George, AAAS, NSF Project Award #1224063, ygeorge@aaas.org
Lance Perez, University of Nebraska, NSF Project Award #1224063, lcperez65@gmail.com
Russell Pimmel, Higher Education Services, NSF Project Award #1224063, russpimmel@gmail.com
Roger Seals, Louisiana State University, NSF Project Award #1224240, cesseal@lsu.edu
Sheryl Sorby, Higher Education Services, NSF Project Award #1224063, sheryl@mtu.edu

Session Description: The TUES Virtual Faculty Development Collaborative (AAAS, LSU, and Higher Education Services) has developed a new community-building model for ongoing, virtual, collaborative efforts among PIs (called, PI Forums). The workshop will explore the formation of PI Forums that address issues appropriate for the TUES program. Workshop topics include defining goals and expected outcomes for a proposed PI Forum and strategies for achieving these outcomes, recruiting participants, and working in the virtual environment.

Discussion Questions:
1.) What would be the focus and goals of an on-going virtual interaction among TUES PIs (i.e., a TUES PI Forum)?
2.) What would be the expected outcomes for such a TUES PI Forum?
3.) What strategies would be used to achieve the expected outcomes?
4.) How would other participants be recruited for a TUES PI Forum?
5.) How would a TUES PI Forum work in a virtual environment?

C5
Session Category: Pedagogy
Session Title: Linking Students to Researchers and Practitioners to Enhance Interdisciplinary Experiential Learning
Co-Facilitators: James P. Lassoie, Cornell University, NSF Project Award #0837489, JPL4@cornell.edu
R. Jamie Herring, Habitat Seven, NSF Project Award #0837489, jamie@habitatseven.com
Karim-Aly S. Kassam, Cornell University, NSF Project Award #0837489, karim-aly.kassam@cornell.edu

Session Description: This workshop presents an innovative Internet-based platform that supports interdisciplinary, environmental education by using real-world case studies. Our ap-
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proach leverages collaborative relationships with practitioners, communities, and researchers to create multi-media case studies that connect them to classrooms and young scholars who represent the next-generation workforce. We will discuss the pedagogy underpinning this approach, specifics relative to its effective use, and ideas for promoting this approach to more broadly meet the goals of TUES.

ConservationBridge is a unique approach in conservation education because it not only uses dynamic “real-world” case studies, but it also provides opportunities to connect students to field practitioners.

Discussion Questions:
1.) What other web-based approaches are being used/developed to enhance meaningful interactions between university students and working professionals?
2.) What are the barriers to using a ConservationBridge-like system across multiple institutions?
3.) What improvements might be made to such a system to overcome these barriers and improve its effectiveness?
4.) What is the appropriate academic level (i.e., high school through graduate school) for a ConservationBridge-like system?
5.) How might a ConservationBridge-like system be expanded to STEM education in general?

C6
Session Category: Pedagogy
Session Title: Does the Design of the SUN Materials Enhance Learning about Biological Energy Transfer?
Co-Facilitators: Ann Batiza, Milwaukee School of Engineering, NSF Project Award #1044898, batiza@msoe.edu
Bo Zhang, University of Wisconsin-Milwaukee, NSF Project Award #1044898, boz@uwm.edu

Session Description: NSF has long funded work to help students understand cellular respiration and photosynthesis based on oxygen-consuming and oxygen-evolving processes. (Mahon et al, 2009; Parker et al, 2012). Our approach using the SUN materials has the potential to help learners to understand how life can occur in environments without oxygen, how organisms can be used to clean up pollution, how new technology might mimic the electron harvesting of photosynthetic reaction centers, and the existing photosynthetic diversity of microbes. Participants will use SUN materials and analyze their design. They will also discuss evidence for their effectiveness and the implications for this detailed approach to learning about biological energy transfer.

Discussion Questions:

2.) In a 2012 edition of CBE-Life Sciences Education, Joyce Parker and colleagues suggest that providing undergraduates with details about the molecular mechanisms of cellular respiration or photosynthesis can be counterproductive, given that many are unable to track matter and energy during the overall processes. In light of this warning, does the detail of the SUN materials help or hinder student understanding of these processes? Why or why not?

3.) Analogical bootstrapping (learning about two unfamiliar processes through a precise one-to-one mapping of their similarities, Kurtz et al., 2001) forms the theoretical basis for the series of sequential experiences suggested for use with the SUN materials. Yet, one is cautioned that misconceptions can arise when the one-to-one correspondence is not precisely defined. We propose that the SUN materials are best used in the context of first a hydrogen plus oxygen explosion and then a hydrogen fuel cell so as to emphasize common language such as the electron donor, the electron acceptor and the work that can be done by moving electrons. Are the early steps needed for optimal learning? Why or why not?

4.) Debbie Reese writes on page 136 in Volume 3 of Models and Modeling in Science Education, “Both the theory of conceptual metaphor (Lakoff and Johnson, 1980, 1999) and transactional analysis (Cantril, 1960) suggest that analogs would be most effective if placed within concrete (material) environments with which learners could interact.” Does translation of these abstract molecular processes into concrete, interactive physical and digital models potentially enhance or detract from learning? Why or why not?

C7
Session Category: Pedagogy
Session Title: Teaching Physics in an Era of Quantitative Biology
Co-Facilitators: Steve Hagen, University of Florida, NSF Project Award #1139906, sjhagen@ufl.edu

Session Description: To an increasing extent, students seeking careers in the biological and medical sciences need a strong grounding in undergraduate physics and mathematics. At the same time, students majoring in physical science increasingly seek exposure to physical aspects of biology. This session will explore ways that physics departments and teachers can contribute to training the next generation of quantitative biologists.

Discussion Questions:
1.) What skills and knowledge do biomedical science students need to acquire in their physics courses?
2.) How can physics courses and materials be revised or adapted to meet these needs?
3.) What are the challenges in expanding the traditional scope of physics courses?
4.) What will be the impact on traditional physics laboratory courses?
5.) What is the role of undergraduate research experience?

**C8**
**Session Category:** Pedagogy
**Session Title:** The Learning Cycle, POGIL, and Microlabs
**Co-Facilitators:** Barry L Kurtz, Appalachian State University, NSF Project Award #1044572, BLK@cs.appstate.edu
Rahman Tashakkori, Appalachian State University, NSF Project Award #1122752, RT@cs.appstate.edu

**Session Description:** The "learning cycle" is a model of learning that involves students in the active construction of knowledge. POGIL is a pedagogical method devised to teach students based on the learning cycle. POGIL is now used in many STEM disciplines. Microlabs are an approach to computer science education that is based on the learning cycle. Microlabs will be demonstrated on tablets during the workshop using problems accessible to a general audience.

**Discussion Questions:**
1.) Why is the exploration phase of the learning cycle so critical for student learning? Can you provide an example from your own discipline?
2.) What can the instructor do during the invention phase to guide students towards a formalization of the concepts being investigated?
3.) The application phase involves applying the new knowledge to different problems in the domain, not just the same problem with different data values. What is a good example of an original problem and a related application to test student understanding in your discipline?

**C10**
**Session Category:** Personnel Development (Faculty, Postdocs, Graduate Student, etc.)
**Session Title:** Creating Effective Virtual Faculty Development Opportunities
**Co-Facilitators:** Heather Macdonald, College of William & Mary, NSF Project Award #1022910, rhmacd@wm.edu
Cathryn Manduca, Carleton College, NSF Project Award #1022844, cmanduca@carleton.edu

**Session Description:** Today's communication tools offer new opportunities for faculty to learn from one another and from experts. In this session we will explore the opportunities and challenges of using virtual events, from short webinars to extended multi-day workshops offered over the course of weeks to months, to engage faculty from various types of institutions, to promote changes in teaching practice, and to establish virtual networks and communities.

**Discussion Questions:**
1.) What are your experiences designing and implementing on-line professional development?
2.) Under what conditions (when and why) can virtual professional development be a strong complement to face-to-face activities?
3.) For various types of virtual events, what are effective strategies for engaging faculty, promoting change in teaching practice, and establishing virtual networks and communities?
then shift to group discussions where participants can share experiences, seek suggestions, and work together to write sample assessment items.

Discussion Questions:
1.) How can formative and summative assessment best be integrated into curriculum development projects?
2.) How does one write and use learning objectives to guide development and assessment?
3.) How does one develop and test assessment items that effectively probe student understanding?

C12
Session Category: Materials Development
Session Title: Creating and Assessing Learning Materials for Teaching
Co-Facilitators: Douglas Ensley, Shippensburg University, NSF Project Award #1140299, deensley@ship.edu

Session Description: Learning materials are no longer just words on a page. The technological ease with which anyone can create interactive, multimedia content raises many possibilities for teaching and content delivery, and raises even more issues about assessment of learning. This session will consist of an open discussion on tools for creating learning materials, the paradigm shift caused by the advent of mobile devices, and successes and pitfalls in their assessment.

Discussion Questions:
1.) What are the pros and cons of various tools for video and multimedia production?
2.) What are the pros and cons of various tools for interactive content such as applets?
3.) How does the increasing importance of mobile devices affect the educational landscape?
4.) How can we measure the effectiveness of individual teaching objects in a multi-layered learning environment?

C13
Session Category: Technology-Based Education
Session Title: Virtual Environments in the Classroom
Co-Facilitators: Stephanie E. August, Loyola Marymount University, NSF Project Award #0942454, saugust@lmu.edu
Jungwoo Ryoo, Pennsylvania State University-Altoona, NSF Project Award # 0817376, jryoo@psu.edu

Session Description: Integration of 3D virtual world environments and digital storytelling into STEM curriculum creates engaging content and provides simulated hands-on experiences. Through small-group discussions, participants will understand the possibilities offered by these technologies, examine models for integrating virtual activities into the curriculum, identify metrics for comparing development and delivery platforms, and network to build relationships for future collaborations. Participants will conclude by constructing a picture of how to best use virtual environments to their maximum advantage.

Discussion Questions:
1.) Which project, platforms, and languages are currently being used to deliver virtual content?
2.) How are/might virtual experiences be integrated with e-books?
3.) How is virtual content being integrated into lesson plans and the curriculum?
4.) Which criteria are critical to consider in comparing these environments?
5.) What effect does platform selection have on dissemination?
6.) What is the value of establishing an interdisciplinary team to create engaging, high quality visualizations?

C14
Session Category: Technology-Based Education
Session Title: Laboratory Instruction in Engineering Education
Co-Facilitators: Usama El Shamy, Southern Methodist University, NSF Project Award #1044585, uelshamy@lyle.smu.edu
Milo Koretsky, Oregon State University, NSF Project Awards #0717905 and 1023099, koretsm@engr.orst.edu

Session Description: The role of the senior laboratory is to facilitate problem-based learning in which fundamental concepts and skills from courses are coupled with experimental and analytical experiences as students work in teams to solve open-ended problems. While this has historically been accomplished with Physical Laboratories, this session explores two alternative modes - the Remote Laboratory and the Simulation Laboratory. Examples of successful implementation in these modes will be presented and participants will discuss advantages and limitations.

Discussion Questions:
1.) What are advantages of using Physical Laboratories? Remote Laboratories? Simulation Laboratories? What are the disadvantages?
2.) Does each of the modes address similar learning outcomes?
3.) What are the challenges with developing and implementing Remote Laboratories? Virtual Laboratories?
4.) Can distance education engineering laboratory classes provide a suitable experience utilizing only Remote and Simulation Laboratories?

C15
Session Category: Pedagogy
Session Title: Large Class Environment That Still Engages Students in the Practices of Science
Co-Facilitators: Fred Goldberg, San Diego State University, NSF Project Award #1044172, fgoldberg@mail.sdsu.edu
Session Description: Engaging students in practices of science in a large-enrollment, lecture-style classroom can be quite challenging, mainly because of time, logistical and personnel issues. After describing (with video clips) some strategies we have used to engage students in experimentation, and constructing and evaluating explanations, I will raise some implementation issues. Then participants will discuss these issues and share other strategies that they have found helpful to engage students in practices of science in such settings.

Discussion Questions:
1.) How can we engage students in hands-on experimentation in a large enrollment, lecture-style classroom?
2.) How can students share their experimental observations and conclusions in a large enrollment, lecture-style classroom?
3.) How can we engage students in constructing and evaluating explanations in a large enrollment course?
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**Biochemical Sciences**

1  
**PI:** Leslie Atkins  
**Institution:** CSU, Chico  
**Project Title:** Collaborative Research: Building a Life Science Curriculum for Elementary Teachers  
**Project Number:** 0942391  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** We have developed, implemented, and tested a semester curriculum in the life sciences for prospective elementary teachers. The curriculum is lab-only, and is designed to build on ideas introduced in a similar introductory physics class. Topics include 'learning-about-learning' and the nature of science.

**Methods & Strategies:** The data collection instruments included a content assessment comprised of the Horizon Research Inc. Life Science assessment and the California Praxis exam, and the biology version of the Views about Science Survey (VASS).

**Evaluation Methods & Results:** The evaluation employed a quasi-experimental design, specifically an untreated control group design with dependent pretest and posttest samples. There were no significant differences between the treatment groups with regard to their understanding of the biology content from pretest to posttest, and from pretest to delayed posttest; both showed strong gains. However, on the VASS, students who experienced the LSET curriculum developed more sophisticated views of the nature of science from pretest to posttest, and from pretest to delayed posttest.

**Dissemination:** The curriculum is being implemented by colleagues at Hope College and high school instructors in Hawaii. This summer (2012) we will be presenting or have requested/submitted proposals to present at SABER, ABET, ESA, and NW Bio.

**Impact:** This project has provided superb opportunities for collaborations between physics and biology faculty, and 2-year and four-year, comprehensive and R1 universities. These have led to the improvement of the teaching skills and a stronger coordination of physics & biology instruction for preservice teachers. Student responses to the course have been overwhelmingly positive.

**Challenges:** To date there have been no unexpected challenges.

2  
**PI:** Gita Bangera  
**Institution:** Bellevue College  
**Project Title:** ComGen: The Community College Genomics Research Initiative  
**Project Number:** 0717470  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** To bring authentic research experiences to Community College (CC) students. Intended outcome: increasing the confidence of CC students in visualizing themselves as scientists.

**Methods & Strategies:** Designed 'mini-graduate school' experience encompassing most aspects of actual research environments; tools for self-direction, self-assessment and meta-cognition; modified the original curriculum to be accommodated into standard cell and molecular biology course curriculum.

**Evaluation Methods & Results:** We used CURE surveys designed by Dr. Lopatto and Dr. Elgin; developed newer assessment tools such as End of Quarter Assessment, Student self evaluations, Receiving faculty survey, alumni survey and other tools developed in house and by our evaluator. We are also assessing the impact on the faculty teaching strategies and the change in the college culture. Our results show an increased confidence among students, adoption of this teaching strategy by faculty, improved culture of research in the college and the approval of a baccalaureate degree by the state of Washington.

**Dissemination:** Dissemination is through national and local conferences and direct contact with faculty interested in developing curriculum. We are currently implementing the modified cell and molecular biology course at 3 CCs in Washington State.

**Impact:** Major impact has been seen with students' confidence in critically analyzing original research articles, tackling demanding research projects, understanding the process of science, and pursuing STEM careers. Many of ComGen alumni are currently pursuing undergraduate, graduate and professional degrees in STEM.

Fellow faculty at our institution and other CCs have embraced this pedagogical method and incorporated it into other courses as well. Based on the success of ComGen Bellevue College has been approved to offer a Biotechnology Baccalaureate degree.

**Challenges:** Although this was a Phase II project, due to some unexpected events we have develop the curriculum entirely in house. The other major challenge has been limited enrollment of students due to financial and time issues. Our solution has been to introduce the research experiences into the cell and molecular biology course.
3
Pl: Ann Batiza
Institution: Milwaukee School of Engineering
Project Title: An Interdisciplinary Approach to Biological Energy transfer-Cross-Institutional Collaboration and Adaptation
Project Number: 1044898
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: Our goals are to adapt the SUN (Students Understanding Energy) physical and digital manipulatives for use at the undergraduate level in four diverse courses at three undergraduate institutions. A two-year college is also observing our efforts. We will also create new materials, establish a multi-institutional learning community, and assess whether or not the adaptation is successful.

Methods & Strategies: The SUN Project is intended to help students develop a model of biological energy transfer through experiences that demonstrate the energy released by moving electrons in both abiotic and biotic circumstances. The instructional materials include physical manipulative that represent components of the chloroplast and mitochondrion that can be configured and manipulated within nested trays. A digital e-book explores the concepts in depth in the context of the nested trays and a David Goodsell drawing.

Evaluation Methods & Results: Data from the trials in the cell biology Biocore honors course and the Biochemistry 507 course at UW-Madison, using randomly assigned discussion sections as treatment vs. control groups will be analyzed with ANOVA analysis. Data from the trials in the single classes at MSOE and UW-Madison will be analyzed using paired t-tests. So far we have collected data from the cell biology course, but it has not yet been analyzed. We will also follow-up with Biochemistry 507 students one year later. In addition, we will develop an interview rubric for a think-aloud protocol to assess the impact of the physical and digital models.

Dissemination: Professor David Goodsell gave an invited keynote address using materials developed for this project. We have created suitcases of manipulative for the MSOE Lending library and have given all participating schools manipulatives. Also, Dr. Ann Batiza and Prof. Carol Hirschmugl gave a Science Bag presentation for about 1,000 people. The e-book will be available online.

Impact: Our project is in its infancy, but now UW-Madison and UW-Milwaukee have multiple sets of the SUN Project materials and the new sets of physical models that highlight evolutionarily important relationships among proteins of the photosynthesis and cellular respiration electron transport chains. We have also created a beta version of the SUN Chloroplast e-book, which David Goodsell shared at a national meeting. The biomolecular engineering department at MSOE has revised the course in which these materials will be tested in the fall. The revision includes a two-hour lab that incorporates use of the SUN materials.

Challenges: Although we originally intended to compare the entire SUN program with a 'business as usual' presentation of cellular respiration and photosynthesis, we had to modify our research design to test only use of certain manipulatives and images. We developed similar study guides for both treatment and control groups. Therefore the SUN concepts were employed by both treatment and control groups, but only the treatment group used the SUN manipulatives. This was because the teaching assistants indicated they had learned a great deal from the SUN training; therefore there was no clear conceptual "business as usual" practice and mindset to recreate. We learned about several implementation issues and will apply knowledge of these to our next trial.

4
Pl: Mark Bergland
Institution: University of Wisconsin - River Falls
Project Title: Developing Computer Simulations Integrating Biomedical Research Techniques with Bioinformatics Tools for Case-based Learning in Introductory Biology Courses
Project Number: 0717577
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To develop an open-ended computer simulation of common laboratory techniques that work with any DNA or protein sequence, along with associated cases based primarily but not exclusively on genetic and infectious disease. To disseminate project results to educators worldwide, via workshops, publications and downloading from the Case It web site (http://www.caseitproject.org/)

Methods & Strategies: The simulation (Case It v6.06) is used (1) by students to analyze and develop cases involving persons associated with the case scenario, and (2) as a tool for undergraduate research applications, such as the HHMI SEA Phage project.

Evaluation Methods & Results: We have considerable assessment data based on standard educational research methodology, indicating that the project is effective at increasing student confidence in and understanding of molecular biology. Primary methods have included pre- and post-tests with internal controls, and focus-group interviews. Details are provided in our most recent annual report.

Dissemination: Case It software can be downloaded free of cost from http://www.caseitproject.org. We have given over 40 workshops and presentations at professional educational meetings and other venues, along with 23 publications and a doctoral dissertation over the course of four TUES grants.
Impact: Based on a survey conducted last November, project materials were used by over 5000 students at 38 educational institutions during the 2010-11 academic year. The actual number of students impacted is larger than this, as project materials were downloaded by educators in 38 states and 48 countries during this time period. Testimonials from these educators indicated that they place a high value on project materials. Specific information is included in our most recent annual report.

Challenges: We did not encounter any unexpected challenges. The latest version of the software, with SNP and expression microarray capability, was released on schedule, along with new cases.

5
PI: Lawrence Blumer
Institution: Morehouse College
Project Title: Collaborative Research: Creating a Bean Beetle Curriculum Development Network
Project Number: 0814373
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We previously developed the bean beetle, Callosobruchus maculatus, as a model organism for inquiry-based undergraduate laboratories in the fields of ecology, evolution and behavior. The goal of this project is to expand the use of inquiry-based laboratory studies with the bean beetle model system.

Methods & Strategies: We are developing a curriculum development network by recruiting teams of faculty to workshops to learn how to work with bean beetles, to learn about the methods and challenges of inquiry-based laboratories, and to begin development of new teaching materials. Members of the Bean Beetle Curriculum Development Network (BBCDN) are developing new materials in the areas of animal physiology, neurobiology, molecular biology, genetics, and developmental biology.

Evaluation Methods & Results: We are evaluating faculty practices in two ways. First, faculty complete surveys on their instructional practices prior to the workshop and following teaching using bean beetles. In addition, we are reviewing video of each new laboratory being taught. We are also evaluating the effects of inquiry-based learning in laboratory courses on the self-efficacy, understanding of the nature of science, and scientific reasoning skills of students using pre-test/post-test with validated instruments.

Dissemination: Newly developed inquiry-based laboratory protocols are broadly disseminated through an established website www.beanbeetles.org and have been presented by several BBCDN members.

Impact: New curriculum has been developed and implemented by 50% of the faculty teams from the first two workshops, and most faculty continue to use bean beetles in their teaching. The majority (75%) of faculty teams from the third workshop are currently developing new curricula. Approximately 1000 students have been exposed to the new curriculum.

Challenges: The great challenges have been (1) getting faculty to provide videotapes of sufficient quality to score and (2) getting students to accurately complete identification numbers on pre-test/post-test assessments in order to match records.

6
PI: Marguerite Brickman
Institution: University of Georgia
Project Title: Project Synergy: Transforming Undergraduate Large-enrollment Science Courses Using Graduate-student 'Scaffolded Apprentices'
Project Number: 0942261
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Our project goal is to foster professional development of graduate students by creating an apprenticeship-model program in which these students helped develop learning materials specifically designed to foster competencies such as scientific argumentation skills in General Education Biology students.

Methods & Strategies: We utilize a Project-based Applied Learning approach (PAL) in which students engaged in questions about biological issues relevant to their lives. Working through these projects, students are challenged to evaluate sources of information and communicate their understanding of scientific claims.

Evaluation Methods & Results: Affective as well as cognitive gains such as argumentation and scientific literacy skill development were collected and compared to students taking a similar class without project instruction. Specifically, we developed a Test of Scientific Literacy Skills (TOSLS) which allowed us to demonstrate that non-majors students in our Project-based classroom made significantly greater learning gains than students in the traditional lecture-based course, even outperforming students in the Biology majors course.

Dissemination: Materials are available online (www.pal.uga.edu) and graduate-students in the faculty development portion presented at several national meetings. Faculty identified in a nationwide survey assessing the importance of skills and competencies were involved in classroom testing curriculum and assessments.

Impact: Over 1200 students in five Gen Ed biology classes at three undergraduate institutions have completed some aspects
A regional planning meeting with faculty teaching Gen Ed Biology courses across our state is planned to enact the curriculum at several local institutions. We will be collecting data on development of students’ scientific literacy skill proficiency as a result of participation in PAL.

**Challenges:** We originally planned to use existing instruments to evaluate student’s scientific reasoning skills, but we found that they were either too limited in scope or too expensive for the number of students we teach. We ended up having to develop and validate our own instrument, which was actually very beneficial in helping us better articulate the learning goals and objectives for our curriculum.

**Goals & Intended Outcomes:** The goals of the Biology Scholars Program are to:
- Empower biologists to be leaders in science education reform;
- Expand & support an interactive community of Biology Scholars committed to scholarly teaching and networking with educators across the country. Participants in all residencies are encouraged to share their experiences through professional society activities.

**Methods & Strategies:** One year residencies are offered to biologists in three areas: assessment, education research and scholarly publication. Each residency offers participants a supportive community for peer mentoring, collaboration and networking with educators across the country. Participants in all residencies are encouraged to share their experiences through professional society activities.

**Evaluation Methods & Results:** A combination of quantitative and qualitative methods has been used. Throughout the residency, participants complete surveys and are in communication with the program’s evaluator. A capstone conference allows participants to come together to report on their progress and findings. This meeting also assists in the development of a community of like-minded educators that continue to interact with one another even after their residency is completed. The program’s evaluator conducts focus groups at the end of the capstone conference.

**Dissemination:** The program has a website http://www.biologyscholars.org/ that thoroughly explains the various residencies offered through the Biology Scholars Program. A recent addition to the website, BSP talks to allows visitors to the site to directly hear from program participants about their experiences in transforming biology education.

Continued dissemination will involve a partnership with the NSF-funded Macademia project so that Biology Scholars can continue to network with one another and find people with similar research interests.

**Impact:** Thus far, 153 biology educators are part of the network of Biology Scholars Alumni. Most of the biologists have participated in the Research Residency. However, in 2011, the Assessment Residency was initiated and had 12 participants. As Biology Scholars conduct and complete their research data collection, many are returning to participate in the Transitions residency. During this residency, Scholars write a draft of their work and assist one another in the editing of their manuscript.

**Challenges:**
- Applicant pool is relatively small so we are reaching out and working with BSP Partners to recruit applicants
- Additional residencies in teaching excellence, grant writing, etc.; working with BSP Partners to sponsor activities
- Travel grants and alumni grants and fellowships are underutilized; working to re-examine eligibility and selection criteria and to work with BSP Partners for wider dissemination

**8**
**PI:** H. David Clarke
**Institution:** University of North Carolina at Asheville
**Project Title:** Creating and Implementing a Research-Infused Botanical Curriculum: Exploring Plants From Communities to Molecules
**Project Number:** 0942776
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** We designed a curriculum to let students do original plant-based research in the context of traditional classroom experiences. This new pedagogical approach has been implemented for three years across multiple courses and departments, and we are assessing its effects on student learning.

**Methods & Strategies:** Our model uses methodological training provided in core first-year courses, then incorporates undergraduate research projects vertically into required biology and environmental studies curricula at the sophomore, junior, and senior levels. We have also adapted this approach for high school students.

**Evaluation Methods & Results:** Undergraduate research students did initial evaluations of curricular modules, which were then implemented in the classroom. Ongoing formative
and summative assessment efforts allow us to determine the effects of our curriculum on classroom students' acquisition of research skills. To date, classroom students have shown significant gains in both botanical knowledge and skills, including the ability to design research projects, analyze data, and write journal-style scientific papers. Peer mentors have also benefited from their participation in this curriculum.

**Dissemination:** We have shared our curriculum across our campus, which has allowed us to get participation from additional departments. Curricular units, as well as this general approach, have been disseminated at several regional and national conferences. We are designing a website for further dissemination.

**Impact:** By infusing research at all levels of the botanical curriculum in several departments, this program has greatly strengthened the research environment at our university. Curricular modules will continue to enhance classroom education, classroom-based research, and student-driven independent research opportunities. This model of research-driven learning will transform basic STEM education at two other universities, with whom we have begun collaborations, as well as with our three partner high schools.

**Challenges:** Our challenges to date have involved determining appropriate methods to use in assessment, and choosing the best times at which to assess our project. Faculty and student colleagues from the Education Department have assisted in ongoing assessment design and execution, as have colleagues at national conferences.

### 9

**PI:** Todd Cooke  
**Institution:** University of Maryland  
**Project Title:** The Physics of Life: Interdisciplinary Education at the Introductory Level  
**Project Number:** 0919816  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** 1) To develop an active engagement pedagogy for effectively teaching fundamental multidisciplinary principles in an introductory organismal biology class; and 2) to compare and contrast student learning attitudes and behaviors in this class vs. conventional biology and reformed physics classes for biology students.

**Methods & Strategies:** 1) Small-group, in-class exercises intended to guide the students toward using their prior biological knowledge to construct conceptual, mathematical, and/or physical models of major principles, and 2) group homework requiring the students to apply the principles encapsulated in those models toward solving problems.

**Evaluation Methods & Results:** We are using pre-post attitude surveys, individual interviews, and videotaped class and group sessions, plus the analysis of student artifacts (tests and homework). Preliminary findings include: 1) many students find it difficult to switch their learning efforts from acquiring isolated facts about different organisms to reasoning from broad principles applying to all organisms; 2) biology students want to maintain scientific silos in that they want to restrict their learning about the physics of life to their physics classes, 3) biology students tend to resist the incorporation of mathematics and quantitative reasoning in their biology classes, and 4) our new pedagogy results in significant improvements in student attitudes toward the first three findings.

**Dissemination:** We are creating a general website for biology education research that will also provide course materials including powerpoint presentations, group active engagement exercises, and epistemological research. We have already started making presentations at scientific and science education conferences, and we anticipate publishing all our research.

**Impact:** In the introductory biology sequence, organismal biology, i.e., the structure, function, and diversity of all organisms, is traditionally taught as a 'forced march' through the diversity and physiology of major phyla. Our overall goal is to transform the teaching of organismal biology: we redesigned the course to focus major biological, physical and chemical principles and we are now using epistemological research to design a new pedagogy for teaching those principles. Our department has bought into this transformation, but we are ultimately trying to create a model course on organismal biology that can readily be transferred to other institutions.

**Challenges:** Student resistance to both pedagogical and epistemological changes. In essence, previous biology courses rewarded these students for their prodigious short-term memories. Although they do appreciate that memorizing for answering multiple-choice questions does not constitute effective learning, they feel as if we have unfairly changed the rules. Our responses are: 1) repeated descriptions of the challenges and the benefits of active engagement learning; 2) repeated opportunities for mastering and applying fundamental principles in lectures, small-group exercises, homework, and essay exams; and 3) repeated encouragement of our colleagues to adopt similar approaches in their classes.

### 10

**PI:** Alison Crowe  
**Institution:** University of Washington  
**Project Title:** Guided Group Activities to Enhance Ways of Learning in Biology: GATEWAY Learning in Biology  
**Project Number:** 0942215  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education
Goals & Intended Outcomes: We propose to develop and test GATEWAY activities in-class, pencil-and-paper exercises done by small groups in a large lecture setting designed to increase student understanding of three particularly important and difficult concepts for college majors in introductory biology.

Methods & Strategies: Two alternate activities were developed for each of the four concepts. Students were randomly selected to perform one of the two activities in groups in a large lecture setting.

Evaluation Methods & Results: Pre/post tests were given within a 48 hour period surrounding the in-class activity. Graders who scored these answers were blind to the different treatment groups. Variability in student ability was controlled using a predicted grade model which we had developed previously. Student learning gains were analyzed using a general linear model.

Dissemination: We are still analyzing the effectiveness of the different activities which we have developed so they have not yet been widely disseminated. However, as part of a different TUES grant, the activities we developed will be tested at five other institutions ranging from community colleges to Research 1 institutions.

Impact: Our study has resulted in an increased awareness among our faculty for the need for an evidence-based curriculum. Faculty have become very interested in testing the effectiveness of different teaching strategies they are employing. We have also received recognition and support from the Assistant Dean of Education in the form of salary support for a postdoctoral fellow to develop curricular assessment tools.

Challenges: The major challenge has been finding sufficient time to complete the research on top of a full teaching load. As all of the senior personnel on this grant are lecturers we do not have dedicated research time. We have relied heavily on undergraduates and graduates, but these students often can only commit to one or two quarters of research. In the future we would propose to hire a postdoctoral fellow to provide more continuity to the research.

PI: Elizabeth Dinsdale
Institution: San Diego State University
Project Title: Microbes, Metagenomes and Marine Mammals: Enabling the Next Generation of Scientists to Enter the Genomic Era
Project Number: 1044453
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The goals include: Inspiring student learning by providing a series of courses in ecosystem genomics, focusing on sequencing the genomes of microbes metagenomes and the California Sea Lion; Engaging students by integrating teaching and research; and Developing material to enable the move into the genomic era, including teaching material, online protocols and evaluations.

Methods & Strategies: Developing courses in genomic theory, hands-on experience in next generation sequencing technology, statistical analysis of genomes and bioinformatics. Provide real research projects where the organisms sequenced and annotated are new to science. Develop web databases to follow the sample through the process and a pipeline to allow for student annotation of genomes and metagenomes.

Evaluation Methods & Results: Conduct pre- and post-tests that assess student learning and perceived ability to conduct independent genomic research. Publish the genomic data, which has been achieved in two journal publications. The students evaluated the course 4.9, 4.4, and 4.8 out of 5 for meeting the three course goals. Student-perceived ability to conduct independent research increased significantly, including conducting projects where: 1) no one knows the outcome, 2) they have input into the process, 3) they need to work as a whole class, and 4) have responsibility for part of the process. The students showed increases in the ability to read primary literature, present the data orally and keep lab books.

Dissemination: Presentations at scientific meetings and symposium, like Sequencer User group meetings. Student presentation of the annotated data. Participation in workshops at the CSUPERB and HHMI to develop curriculum for genomic education. Planned publications describing the courses and educational outcomes.

Impact: Students enjoy the courses, are learning up-to-date technology and many are pursuing genomic careers. Students have received employment in the sequencing industry. Several faculty have used the data and started to conduct new projects with the technology and trained students. The institution has received funding from industry sources to promote genomic education, and several news and magazines articles, such as Genome Technology have been published. The courses have been taught in international institutions in Brazil and Mexico. Courses have been replicated at two universities. Last, pursuing ways for the Sea Lion Genome to be annotated by students across the California State University system. An international consortium is using the data to research cancers in mammals.

Challenges: Logistics to conduct the hands-on sequencing course was difficult because there is a high potential for contamination of the environmental DNA with the linker DNA. Therefore, the process and the students need to move to three separate buildings during the course. Tracing of the sample though the process is difficult, because the important information is in the students’ lab books not with the instructors, therefore a website was built to enable the students to upload the data for all to see. The manipulation of large data sets is
Poster Abstracts

difficult and required a pipeline to be constructed to ensure the data was uploaded to annotation sites ready for the students to analyze.

12
PI: Clarissa Dirks
Institution: The Evergreen State College
Project Title: SPARST: Assessing the Process of Science
Project Number: 1044786
Type: Phase 1/Type 1 - Exploratory
Focus: Assessing Student Achievement

Goals & Intended Outcomes: Our goals are to better understand when undergraduates acquire mastery of certain science process and reasoning skills. Our outcomes are to create a biology context-dependent, content-independent test to assess science process skills such as experimental design, graphing, data analysis and science communication.

Methods & Strategies: We are using common misconceptions identified by biology faculty, the literature, and our faculty advisory board to develop learning outcomes we will test. The questions are vetted with the faculty for validity and with students for clarity. The test will be iteratively modified based on statistical analyses of pilot testing at several institutions.

Evaluation Methods & Results: We will pilot the test at several institutions and use the data for item analysis. The test questions and specific distracters for certain questions will be modified as a result of the pilot data. Through rigorous analyses by our statistician, evaluator and faculty advisory board, we will continue to improve the test until it is complete. We will administer the final version of the test at many institutions and investigate if students' acquisition and mastery of science process skills change throughout their undergraduate education; the data will also be analyzed to determine how skill level changes at institutions or by teaching practices.

Dissemination: We will continue to attend meetings where we describe the tool and our development processes; thus far we have been successful in recruiting more institutions to participate in piloting the instrument. We will publish both the learning outcomes and the processes we used to develop the tool and will also publish the findings.

Impact: An important impact our assessment tool has had is opening dialog with faculty. In developing the tool we had many rich conversations about specific aspects of the kinds of skills students should acquire throughout their undergraduate education. We also realized that we view certain things differently, such as what is a good hypothesis. We also discussed the kinds of graphs students should be exposed to and know how to read and interpret by their freshman and senior years. We have recorded very rich data related to this dialog and intend to publish it either in a separate publication or in the discussion section of how we developed the instrument.

Challenges: As described above, the 10 faculty involved in the project realized that we interpret and teach science process skills differently and that we need to have more dialog to reach consensus. We believe it is important to continue this dialog so we can create materials and educate other biology faculty in how to best teach these skills. We also encountered the difficulty of writing multiple-choice questions to assess some areas of science process skills, particularly science communication.

13
PI: Diane Ebert-May
Institution: Michigan State University
Project Title: Faculty Institutes for Reforming Science Teaching (FIRST IV) for Postdoctoral Scholars
Project Number: 0817224
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: We are providing professional development in teaching and learning for 200 postdoctoral scholars (PDs) via a national team of faculty leaders who are implementing professional development workshops, mentoring PDs, and advancing their own scholarship in teaching and learning. The PDs complete a two-year long program and produce an entire, introductory biology course that is inquiry-based and learner-centered.

Methods & Strategies: Five different leadership teams of faculty implement the workshops and provide long-term support of postdocs for implementation, analysis and dissemination of project outcomes. We recruited two different cohorts of PDs (100 each) who participate in two years of professional development that includes teaching after each workshop.

Evaluation Methods & Results: We are using a mixed evaluation approach consisting of objective review of videos of PDs’ teaching practice and courses developed, and self-reported data from the PDs and their students. Expert review of teaching videos shows that all PDs are incorporating interactions with students in their teaching. Self-reported data from the PDs show greater support for concept-centered, student-focused teaching practice than information-transfer, teacher-centered approaches. Most students believed that they made high gains in knowledge and understanding, their ability to think about ideas and problem solve, their ability to communicate effectively, and their responsibility for learning. To date, the PDs have developed 52 courses in biology and are teaching many of those courses.

Dissemination: We published two papers and four are in progress that focus on the effect of FIRST IV training on
cognitive level of learning objectives and implementation of backward design, correlation between student approaches to learning and perceptions of science, comparison of self-reported and directly observed data on teaching, and the listserv. The PI conducted 37 seminars and workshops that disseminated the research findings and the professional development model of FIRST IV. PDs are disseminating FIRST IV within their departments and national meetings (e.g., ESA) via seminars and workshops.

**Impact:** (1) All postdocs incorporate some level of student interaction in their teaching. (2) PDs choose instructional designs to create learner-centered courses. (3) PDs are evaluating, adapting, and using instructional resources as they build their introductory biology courses. (4) PDs are practicing aligning their objectives, assessments, and instructional design for implementation in their courses. (5) PDs provide each other and receive expert feedback from Regional Team Leaders on teaching practice and materials. (6) PDs are active members of the FIRST IV network (listserv). (7) PDs are competing for and gaining faculty positions for which strong evidence about quality teaching is required along with their expertise in research. (8) PDs are beginning their academic positions with an entire inquiry-based, learner-centered course designed and implemented.

**Challenges:** Postdocs submitting their assessment data according to the schedule -- we are monitoring more closely and sending more frequent reminders.

**14**

**PI:** Margaret Franzen  
**Institution:** Milwaukee School of Engineering  
**Project Title:** Connecting Research Labs and Classrooms: A Role for Physical Modeling Projects in the Undergraduate Curriculum  
**Project Number:** 1022793  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The CREST Program seeks to improve undergraduate education by bringing current research topics in the molecular biosciences through the use of physical models and innovative student-centered materials. The process of science will be emphasized more in the targeted classrooms.

**Methods & Strategies:** CREST combines an instructional materials development project with an opportunity for undergraduates to interact in a meaningful, but cost-effective and minimally invasive manner, with a research laboratory to create a physical model of the protein studied in the lab.

**Evaluation Methods & Results:** CREST modeling students are interviewed to determine the impact of the program on career goals, confidence in pursuing science careers, and understanding of the nature of collaboration in the community of science. Classroom assessment of the impact of the curricular materials is being done using SALG pre and post-course surveys, and content-specific learning gains are being compared in cohorts before and after the inclusion of the materials in the classroom. Assessment strategies are institution-driven and therefore varied in the 8 institutions incorporating materials in the classroom.

**Dissemination:** The project centers on 6 regional institutions. We have added a remote site in Florida to the project. Some of the materials developed in the project are also being piloted and assessed in an eighth institution, and a novel Model Lending Library and website will make the materials more broadly available.

**Impact:** CREST students express greater confidence in succeeding in science careers. Students at non-research institutions benefit the most from interacting with research mentors. CREST faculty benefit from interaction in community and transition to more student-focused learning in the classroom; they are also infused with enthusiasm from the opportunities to work with students to dig deeply into a research topic they can use in their classroom. Researchers report having a fresh perspective on their research from interacting with students in the modeling projects.

**Challenges:** Coordinating IRB approval at nine vastly different institutions has been a massive undertaking! We have had to focus our data collection and continually review our goals and assessment strategies to consider whether the information we hope to gain is worth the effort to get approval at so many institutions.

**15**

**PI:** Tamar Goulet  
**Institution:** University of Mississippi  
**Project Title:** Class Generated Community Clicker Cases: Testing a Novel Pedagogic Approach Connecting Science and Non-Major Students in Large Introductory Biology Classes  
**Project Number:** 0942290  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** To empirically test the efficacy of a novel pedagogic approach, Class Generated Community Clicker Cases (CGCCC), as an alternative technique to lecturing in a large, non-majors introductory course. Students’ data gathering advance the course content coverage, and creates personal investment in the subject matter.

**Methods & Strategies:** CGCCC is an innovative way to integrate and capitalize on the strengths of both clickers and case studies. In CGCCC, students are given questionnaires that they fill out by interviewing members of their community, thereby creating the cases. Answers are collected in class via clickers and class discussion.
**Evaluation Methods & Results:** The effectiveness of CGCCC versus lecturing were assessed using 4 indicators, 2 dealing with knowledge of biology, and 2 dealing with students' perceptions of the study of biology. The indicators were: 1) Extent of students' factual knowledge; 2) Extent of students’ ability to assimilate and apply the learned information; 3) Rates of student attendance in the class; and 4) Extent of self-reported student satisfaction with the course. Data collection occurred from Spring 2010-2012 semesters. Data will be analyzed in the summer and fall.

**Dissemination:** Dissemination includes: Formation of a CGCCC biology syllabus made available to other institutions; Training and mentorship of graduate students to be educators as well as scientists; Regional workshops which will affect the teaching practices of faculty at multiple institutions; and publication in journals and conference presentations.

**Impact:** Impacts of project: potentially dramatically alter the way in which science content coverage is approached, both in non-majors and major introductory classes. Therefore, this project will affect both students and faculty. Due to the workshops and other dissemination venues, the project’s influence will transcend the University of Mississippi.

**Challenges:** The teaching approach being tested relies on students conducting interviews and reading the textbook. A challenge emerged of having the students take the interviews seriously. We therefore assigned points for the interviews. To address reading the book, we created an assignment where students had to write the page numbers that pertained to the interview questions. Students received points for this assignment.

16

**Pi:** Joel Hagen  
**Institution:** Radford University  
**Project Title:** SUMS4Bio: Strengthening Undergraduate Mathematics and Statistics Education for Biologists  
**Project Number:** 1044110  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  
**Goals & Intended Outcomes:** Design and implement Math for Biology and Stats for Biology courses. Link topics in MATH course with BIOL 131 Ecology and Adaptation and BIOL 160 Introductory Seminar. Link topics in STAT course with BIOL 232 Organismal Biology. Integrate math skills throughout the biology curriculum.  
**Methods & Strategies:** Mathematics and Statistics faculty members work with Biology faculty to design the new MATH and STATS courses. Teams work on coordinated activities that link Biology skills and concepts with appropriate Math/Stats skills and concepts in the new courses and in existing BIOL courses.

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**Evaluation Methods & Results:** Our external assessment coordinator (Andrew Kerkhoff, Kenyon College) is developing an assessment instrument. This will be administered during the first week of BIOL 131 (fall semester) and the first week of BIOL 132 (spring semester). Because of the one month break between the end of BIOL 131 and the beginning of BIOL 132, we hope to collect data that reflect long-term achievement of Math skills practiced in BIOL 131, 160 and MATH 119. This instrument will also be administered at the end of the sophomore year (after BIOL 232 and STAT 219).

**Dissemination:** Various faculty members are presenting preliminary results at the Ecological Society of America meeting, ABLE meeting, and a Math/Biol conference and workshop sponsored by NIMBioS. One faculty member will participate in a summer BioQUEST workshop on teaching with data.

**Impact:** The new MATH and STAT courses will be taught for the first time during the 2012-2013 academic year. We anticipate a measurable increase in students' quantitative skills as a result of linking MATH/STAT and BIOL courses. We anticipate increased collaboration between MATH/STAT and BIOL faculty. We anticipate greater use and integration of quantitative approaches throughout the BIOL curriculum.

**Challenges:** Development of interdisciplinary approaches has been a challenge, particularly for MATH/STAT faculty who do not have extensive backgrounds in biology. The grant provides funds for two MATH/STAT faculty members to participate in BIOL 131 lectures and labs. One of these faculty has continued on with BIOL 132 (Cell Biology). We have organized yearly retreats to share ideas among MATH/STAT and BIOL faculty members. We have also instituted a seminar series with speakers from both our institution and invited speakers from other colleges and universities.

17

**Pi:** Heather Henter  
**Institution:** University of California, San Diego  
**Project Title:** The San Diego Biodiversity Project: Integrating Authentic Research and Collaboration into the Biology Curriculum  
**Project Number:** 1140640  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  
**Goals & Intended Outcomes:** The mission of our project is to engage students in the process of authentic research and foster collaborations between students in different sub-disciplines of biology. Our goals for every student are: 1) apply the scientific method to generate new knowledge about biodiversity, 2) find satisfaction in addressing real-world issues, and 3) understand the collaborative nature of science. Outcomes are defined below.
Methods & Strategies: We are developing research modules for multiple courses in which students are using DNA sequencing and bioinformatics techniques to create a biodiversity inventory of a wildlife refuge adjacent to campus. Each course will contribute different types of data to the database, but through our website students will access all the data to compose and address timely, compelling, and original questions about biodiversity identification and conservation.

Evaluation Methods & Results: We intend to use a pre- and post-test paradigm to determine if the research modules we have designed for our lab classes produce a measurable change in student attitudes and help students achieve the learning outcomes we have described. Specifically, we plan to use a validated, pre-existing assessment tool called the CURE survey (Lopatto, 2008) that will measure the effects of the lab experience on students views toward science, confidence in their ability to understand how science is done, and career goals. Each course will develop additional questions to assess discipline-specific mastery of course content. An assessment expert will review our assessment plans.

Dissemination: The website and associated database will be the primary means of disseminating information. Videos that explain the project, lab protocols, student projects, and data will be available. Students will communicate their results in our student-run research journal. Faculty will publish in science education journals and attend professional meetings, the first of which will be the Association for Biology Laboratory Education meeting in June, 2012.

Impact: Although our funding does not start until July 1, 2012, the pilot projects have already fostered interaction among diverse molecular biology and ecology faculty and prompted discussion of assessment and outcomes-oriented teaching methods. At least one faculty that is not a PI has been inspired to use the CURE survey. Other instructors are initiating an assessment working group. We anticipate this will grow once the website is operational and provides more avenues for communication. As described below, students have also been enthusiastic. We anticipate that this enthusiasm will motivate other faculty to incorporate more of a collaborative research culture into their curricula. The impacts on students are described under Expected Outcomes but in summary we hope that undergraduate students will learn to think like scientists and understand that they can contribute to original research.

Challenges: The SDBP will involve over 2000 students in authentic and collaborative research. Making sure that each of these students feels personally connected to the project is a challenge that we will use technology to address. The database and website will allow students in different courses to post their own data, interact, access the data of other students, and thus see their work in context. Faculty will post short lectures on the website that can be used in courses other than their own, to foster our interdisciplinary approach. An additional challenge we anticipate is that students may get frustrated with the difficulties of doing original research. Students will have to grapple with incomplete or poor quality data, tedious tasks, and ambiguous conclusions. We hope that the enthusiasm generated by addressing compelling research questions will offset these possible frustrations.

18
PI: James Hewlett
Institution: Finger Lakes Community College
Project Title: Collaborative Research: Community College Undergraduate Research Initiative (CCURI)
Project Number: 1118679
Type: Phase 3/Type 3 - Comprehensive
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The overall goal of the project is to support the implementation of undergraduate research programs at the community college level. CCURI will be testing a model for integrating a research experience into two-year science programs at 16 partner institutions around the country.

Methods & Strategies: The CCURI model includes the employment of a case study method of instruction at the introductory course level to build research skills and ‘hook’ students into the research questions that form the foundation of the research program at the partner institutions.

Evaluation Methods & Results: A formative evaluation has been used to measure the effectiveness of the initial workshops used to help the partners develop a four-year strategic plan for their research programs. In addition, a critical thinking assessment tool (CAT) has been implemented at 5 of the partner institutions. Data are not yet available. The evaluation plan includes measures of student, faculty and institutional impact and will utilize a variety of tools to capture the deliverables.

Dissemination: Currently, dissemination activities consist of a series of 5 strategic planning workshops and the project website (www.ccuri.org). CCURI will be participating in the fall STEMtech conference and will be holding a series of undergraduate research symposia in years 3 and 4 of the project.

Impact: The current project is in its early stages, but is an extension of previous phases of development. At Finger Lakes Community College, the impacts include the development of three research courses, the integration of research into a degree program (Biotech), and the development of infrastructural elements, including IRB and IACUC. A previous implementation of the CAT instrument included preliminary data to suggest that the critical thinking abilities of a graduating community college undergraduate researcher are similar to what you would find in a college senior.
Poster Abstracts

Challenges: CCURI is testing a model for integrating a research experience into a two-year institution. The primary barrier we have encountered is the diverse nature of the partner schools. In order to handle this challenge, we have created a flexible structure for partner schools to develop a strategic plan that is specific to their institutional goals.

19
PI: Sally Hoskins
Institution: City College of New York
Project Title: C.R.E.A.T.E. Cornerstone--Inspiring Undergraduates to Persist and Succeed in the Biology Major
Project Number: 0942790
Type: Phase 1-Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Goal: Use an adaptation of the C.R.E.A.T.E. strategy for demystifying and humanizing science through intensive analysis of primary literature coupled with email surveys of scientist-authors to facilitate first-year students' persistence in the Bio major, success in core courses and interest in research.

Methods & Strategies: I am using the C.R.E.A.T.E. pedagogical toolkit, including concept mapping, cartooning, figure annotation, paraphrasing, student experimental design and grant panels, as applied to primary literature suitable for first year students, as well as newspaper and popular-press accounts of scientific investigations.

Evaluation Methods & Results: Students are being evaluated using a suite of instruments including two critical thinking tests, a concept mapping assessment, a Likert-style survey of student attitudes, self-assessed abilities and epistemological beliefs about science, and an assessment of experimental design ability. The course and data evaluation are in progress. Data examined to date suggest that the single-semester course produces significant shifts in students' experimental design ability, attitudes about science, self-rated reading/analysis/data decoding ability, and aspects of their epistemological beliefs.

Dissemination:
- June 2012: Results will inform workshops to be held as part of NSF 10201443
- July 2012: Presentation at Society for Developmental Biology meeting
- October 2012: Workshop proposed for AAC&U meeting
- A C.R.E.A.T.E. Cornerstone teaching handbook will be completed.

Impact: The new first-year C.R.E.A.T.E. Cornerstone (CC) course is in early stages of implementation. To date, CC students have expressed strong interest in starting independent research projects in faculty labs this summer, a process that usually begins much later (in year 3) in our department. I anticipate that because they have a better understanding of the research process than students who have not taken CC, these students will persevere through laboratory setbacks that would deter the typical student. Tracking will determine overall persistence in the major and success in Bio core courses.

Challenges: First year students on my campus are on average poorly prepared for tasks involving close reading, writing, and developing, expressing and defending propositions or arguments based on interpretations of data. I have added new approaches to the preexisting C.R.E.A.T.E. toolkit (for example multiple assignments involving paraphrasing and writing/revising/rewriting) to work on filling these gaps. Short attention spans of the first-semester college students have necessitated careful scaffolding of classroom activities and increased variety of such activities in each class session.

20
PI: Kristin Jenkins
Institution: National Evolutionary Synthesis Center
Project Title: Show Me the Evolution! Assessing Effectiveness of a New Teaching Resource
Project Number: 0837015
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goals of this project are to assess, and then improve, the educational value of the Evolution in the News program, as well as to develop more targeted dissemination strategies and pedagogical recommendations for classroom integration.

Methods & Strategies: Evolution in the News program uses a current news item as a jumping off point each month to showcase an important evolutionary concept, integrating an illustrated article, a multimedia podcast featuring scientist interviews, supporting educational materials, and links to popular and scientific literature.

Evaluation Methods & Results: Students took a pre-survey before watching the podcast or reading the text story, and answered the same questions in a post-survey. The surveys probed student understanding of the basic evolutionary concept in the story. The post-survey included questions about how students access scientific information, and their personal preferences for information delivery. Faculty responded to a follow up survey in which they shared their impression of the effectiveness of the program with their students. Overall, the results of the assessment indicate that the program is a valuable classroom resource across a broad range of audiences, and in a variety of classes.

Dissemination: Evolution in the News stories are available through the Understanding Evolution and NESCent websites, YouTube, and iTunes U. The developers promote the materials...
at various educational conferences and have published a paper on the program.

**Impact:** Overall, the results of the assessment indicate that the program is a valuable classroom resource across a broad range of audiences, and in a variety of classes. Both students and teachers found the stories engaging and informative. Student responses indicated that the story took a complex issue and simplified it, making it easier to learn the material, and 90% of the students reported the program being an effective way to convey evolutionary biology principles. The majority of faculty felt the program helped them to identify student misconceptions about evolutionary concepts.

**Challenges:** No challenges.

**21**

**PI:** Thomas Jones  
**Institution:** East Tennessee State University  
**Project Title:** Virtual Ecology: An Inquiry-Based Online Learning Environment  
**Project Number:** 0941968  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goals were to create virtual simulations of 'classic' experiments in ecology and evolutionary biology, and to assess their efficacy as learning tools.

**Methods & Strategies:** We used a mix of online and paper surveys to collect student demographic information and assess their experiences using the models. We also conducted objective pre/posttests to assess student learning outcomes.

**Evaluation Methods & Results:** We have created over a dozen simulation models which are freely available on the website virtualbiologylab.org. Our assessment found that a majority of students enjoyed working with the models and found them to be helpful learning tools, particularly in areas of data interpretation and experimental design. Our objective assessment found significant conceptual learning gains in all courses tested.

**Dissemination:** We have published two descriptive papers in an educational journal, and will publish our assessment results once the final round is competed (spring 2012). We have also presented at two professional meetings and a departmental seminar.

**Impact:** Virtual Biology Lab models have been incorporated into the standard curriculum at ETSU and the three other institutions which participated in the CCLI type I project. We know from communication with faculty, and estimate from Google Analytics, that our models are likely being used in curricula at other institutions including: four-year colleges and university, community colleges, and at least one high school.

**Challenges:** The main unexpected challenge has been addressing changing technology. Tablet and mobile computing is quickly becoming ubiquitous, which is changing how we will develop models in the future. We are looking into development environments which can be 'built' for multiple platforms.

**22**

**PI:** Susan Keen  
**Institution:** University of California at Davis  
**Project Title:** Learning Modules to Enhance Understanding of Animal Development  
**Project Number:** 0942294  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Students who learn from this project will be able to outline the morphological events within a developmental sequence for a range of organisms and will propose molecular mechanisms that produce the observed morphological changes. Users will also identify a phylogenetic signal in development.

**Methods & Strategies:** Students use animations embedded in a self-guided learning script to explore development. Developmental sequences are parsed into short sections where users describe what they see, interpret events, propose mechanisms, and predict outcomes of animated experimental manipulations.

**Evaluation Methods & Results:** Student evaluators critique content, explanation, and style as the animations are made. The learning value of the modules is under test at a community college where one instructor teaches two sections of a single class. One section has lectures, text, and drawings, whereas the other section has additional access to learning modules. In the first trial, exam scores were not different between treatments; analysis showed limited student use of the added resource. In a second trial, students earned points for module use; analysis is underway now. Interviewed students liked modules in both trials.

**Dissemination:** Dissemination to other users is limited to 2 community colleges and to colleagues at my campus. I presented the modules at the national meeting of the Society for Developmental Biology in July 2011 and contacted other long-term biology animators. I plan to form a research network of animators.

**Impact:** Students at UC Davis who are interested in biological research reported that the animations were fun and very educational. Community college students enjoyed the visual aspects of the animations and reported increased interest in
developmental biology, but we have not shown that they score better on exams, so far. I have really enjoyed interacting with the campus Center for Excellence in Teaching and Learning (as part of assessment) and with colleagues at the community college. I think this will continue and expand.

**Challenges:** Community college students who had access to the modules did not utilize them fully because there few course points offered as a reward. A second trial with a greater reward is underway now. Community college users asked for more written explanation of the animations; we plan instead to add text explaining that the module design encourages students to figure out how parts of development operate. At the end of each topical section, we will provide information to confirm or modify a user’s understanding of that section.

23
**PI:** David Koetje  
**Institution:** Calvin College  
**Project Title:** Leveraging Laboratory Activities to Achieve Educational Reforms  
**Project Number:** 1140767  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Develop and implement laboratory modules that connect biological, mathematical, and chemical concepts and competencies. Strengthen scientific teaching strategies and teaching/learning scholarship in STEM departments. Expand these reforms beyond our department and institution.

**Methods & Strategies:** Our interdisciplinary team of faculty and students is preparing mini-investigations for two introductory biology courses. We are also planning faculty development workshops to improve scientific teaching pedagogies and SoTL competencies for early implementers and collaborators.

**Evaluation Methods & Results:** We are using laboratory-level formative assessments to establish baselines that guide teaching choices and inform programmatic changes. For our program-level assessments, instructors and observers will relay what is happening in each laboratory section so that our team can gain an overarching perspective to inform future revisions. During evaluation-level assessment, we will work on a periodic basis with an evaluation team to audit evidence of progress against proposed goals and make changes as necessary to reach to our goals.

**Dissemination:** We will be submitting lab modules for publication in national databases. Workshops based on this project will be presented at various professional conferences. We will also publish in peer-reviewed journals details about our development process, module design, and effects on learning.

**Impact:** Because its focus is integrative and investigatory, we expect our project to help students and faculty to de-silo the bioscience learning environment. To this end, we are writing student and instructor manuals that provide overviews of the integrative science concepts and tips for teaching the integrative science competencies involved. We expect that this project will lead to our involvement in larger collaborative efforts such as TUES Type 2 or 3 projects that align undergraduate STEM education with the complex societal challenges of the 21st century.

**Challenges:** Our project is slated to begin in June 2012, so at this time (April) we have not yet encountered any unexpected challenges.

24  
**PI:** Paula Lemons  
**Institution:** University of Georgia  
**Project Title:** Case Study Teaching: How Do Questions and Emotional Engagement Impact Student Learning?  
**Project Number:** 0920264  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** We (1) tested the hypothesis that higher-order clicker cases will more greatly enhance students’ critical-thinking skills than lower-order clicker cases; and (2) expanded the NCCSTS case collection with the addition of clicker cases specifically designed to promote critical thinking.

**Methods & Strategies:** Three instructors each taught two sections of introductory biology using clicker case studies; one section with higher order questions and the other with lower order. We compared the performance of 2,000 students using pre- and post- tests to determine if their critical thinking and test performance improved.

**Evaluation Methods & Results:** We compared student performance using the Watson-Glaser Critical Thinking Appraisal Inventory, a multiple-choice biology test drawn from the AP exam, and 2 essay questions requiring content knowledge and critical thinking. Results were analyzed with standard statistical tests. Students showed significant learning gains from pre- to post-semester on all measures. Current data analysis suggests students did not experience differential learning gains in higher-order sections compared to lower-order sections. We have yet to complete analysis for differences in emotional engagement between groups.

**Dissemination:** We disseminated our work at the 2011 NCCSTS Fall Conference. We submitted our work for presentation at the upcoming meeting of the Society for the Advancement of Biology Education Research. Two manuscripts are completed; three are in development. Six clicker cases are submitted for review.
**Impact:** The 2,000 students who participated in our study improved their critical thinking skills and their performance on multiple choice and essay exams in the subject matter dealing with the clicker cases. This demonstrates that case studies can be effectively used in large classes. Once the data are published, faculty creating case study questions will be guided in their construction by referring to our results. Faculty and graduate students who helped create the cases and those who evaluated the clicker questions within the cases, reported gaining insights about how to design higher-order cases.

**Challenges:** The higher-order clicker cases were perceived by some students to be too difficult. In fact, in one higher-order section, student motivation for learning went down from pre-to post-semester, as assessed by an independent researcher for an unrelated project. We did not uncover this potential problem until our data collection was almost complete. We think higher-order clicker cases in and of themselves may not provide enough support to promote greater critical-thinking learning gains. Rather, additional scaffolds (e.g., online tutorials, guided practice) may also be necessary.

**25**

**PI:** Tammy Long  
**Institution:** Michigan State University  
**Project Title:** Reforming Introductory Biology at MSU: Does It Make a Difference?  
**Project Number:** 073692  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** Our project goals are to: (1) design a reformed version of introductory biology for life science majors; (2) implement the reform across multiple sections and instructors; and, (3) evaluate impacts in terms of subsequent performance in upper-division courses and attrition from STEM majors.

**Methods & Strategies:** We used a Backward Design approach to build a reformed course that: (a) engages students in authentic science practice (e.g., modeling, data analysis, scientific argumentation), and (b) is grounded in theory about how people learn (e.g., collaborative learning, frequent formative assessment, active learning, etc.).

**Evaluation Methods & Results:** We are evaluating student outcomes at 3 levels. (1) In the reformed course, student achievement is measured as performance on a case-based, comprehensive final exam that assesses multiple competencies across a range of Bloom levels. Long-term impacts of reform are measured as: (2) students’ subsequent achievement in upper-division courses at the levels of course (final grade), assessment (exam score), and item (by Bloom); and, (3) rates of attrition from STEM majors, measured by comparing students’ declared majors at the time of enrollment in the reformed course and again at graduation.

**Dissemination:** Our materials and approaches have been disseminated extensively - both on campus (with non-project faculty teaching in the introductory biology course) and through the FIRST IV project, which provides professional development to over 200 postdoctoral scientists. Our course products serve baseline materials that faculty and postdocs use in their existing form and/or modify to suit their specific course needs.

**Impact:** Students enrolled in reformed sections of introductory biology differ from students in non-reformed sections in terms of their patterns of attrition and retention in STEM majors. However, performance in upper-division courses is more nuanced. Our analyses of exams from introductory and upper-division biology reveal substantive differences in both the nature of assessments and Bloom levels targeted, suggesting low alignment across the curriculum. Discussions have begun at program, department, and college levels regarding goals for student learning in the life sciences.

**Challenges:** Engaging faculty cooperation in our assessment of long-term impacts proved most challenging. For example, even with faculty who agreed to participate in the study, they were reluctant to share assessment data (exams, scores). In addition, tracking students is particularly challenging as students did not necessarily follow the curricular trajectories we had anticipated in our research design.

**26**

**PI:** Gili Marbach-Ad  
**Institution:** University of Maryland  
**Project Title:** Assessing the Impact of a Disciplinary Teaching and Learning Center on Current and Future Faculty Professional Development  
**Project Number:** 0942020  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** We aim to (1) cultivate Faculty Learning Communities, innovative teaching strategies, and professional development for faculty and graduate students, and (2) conduct a comprehensive evaluation of the impact of the disciplinary Teaching and Learning Center on curriculum and pedagogical change.

**Methods & Strategies:** The project is assessing the impact of various institutional strategies (teaching communities, workshops, visiting scholars, travel to conferences, and individualized mentoring) on the development of teaching expertise and enthusiasm for teaching innovation in faculty and graduate students.

**Evaluation Methods & Results:** Three different surveys with both quantitative and open-ended questions were developed for faculty, GTAs, and seniors. We interviewed a sample of faculty and GTAs, and developed a structured rubric to observe
classes. We found that across all three populations, most of the respondents placed high importance on skills and goals that are consistent with national recommendations for teaching. However, there was a gap between what faculty believe is important in science education and the practices they use in their classrooms. Feedback from faculty and GTAs was used to develop professional development activities.

Dissemination: We have presented our work at AERA (2010, 2012), NARST (2010, 2011, 2012), Lilly (2010, 2011), SENCER (2010), and AAC&U (2011). Eight papers resulting directly from the TLC’s efforts have been published, and two more papers have been accepted for publication. Two additional papers are in preparation.

Impact: Based on survey feedback, we have implemented workshops on specific topics of interest to faculty. We initiated more teaching communities. Because of our travel funding for faculty and graduate students to attend and present at science education conferences, a growing number are attending these conferences. In addition, more faculty and GTAs are seeking individualized mentoring from TLC staff. We are now in the process of institutionalizing center activities and are consulting with other campus units on new initiatives such as developing faculty peer evaluation processes within departments.

Challenges: We are interested in showing that faculty members not only changed their beliefs about teaching and learning, but also that they have changed their practices in the classroom. Obtaining evidence for changes in the classroom is very difficult, since using a small sample of classes is misleading and observing a large number of classes is logistically challenging. To overcome this, we developed a rubric for classroom observation that can be used both for faculty peer evaluations and for assessing grant outcomes. A pool of GTAs and the outside evaluator are using these rubrics to observe classes.

27
PI: Jenny McFarland
Institution: Edmonds Community College
Project Title: Defining and Assessing the Core Principles for Undergraduate Physiology
Project Number: 1043443
Type: Phase 1/Type 1 - Exploratory
Focus: Assessing Student Achievement

Goals & Intended Outcomes: Goal 1. Identify the core principles (or core concepts) of physiology. Goal 2. ‘Unpack’ 3 core principles into Conceptual Frameworks of component ideas. Goal 3. Create and validate a Physiology Concept Inventory. Goal 4. Foster a diverse community of physiology faculty interested in this research.

Methods & Strategies: We are a team of 6 physiology faculty from diverse institutions. We are working with a physiology faculty from around the country to identify core principles as a community, create and validate Conceptual Frameworks for 3 core principles, identify misconceptions and validate our concept inventory.

Evaluation Methods & Results: We are using a modified Delphi approach and validating each step of our work by first working within our team and then verifying this work with a diverse group of physiology faculty and modifying our work given the feedback from other faculty. This approach is time-consuming but effective and serves to build a broad base of interested and engaged physiology faculty who are enthusiastic about using our work knowledgeable about the process and the prospects of applying it to teaching, learning, assessment and course and curriculum development.

Dissemination: We have published in Advances in Physiology Education and have (or will) presented posters & workshops at meetings, including Experimental Biology (2011 and 2012), Human Anatomy and Physiology Society (HAPS 2011 and 2012), Northwest Biology (2011 and 2012), Biology Leadership Conference (2012), NABT (2012).

Impact: This work has impacted the project team and faculty who have participated in workshops and surveys by sharing the core principles (which are used to structure student learning, assessment, courses and curricular change). Murray Jensen’s (PI) NSF-funded physiology POGIL development is using our APS paper as a way of focusing their work and assessment on the core concepts in physiology. The Conceptual Frameworks being used to frame teaching and to help students scaffold their learning and identified misconceptions actively being considered for assessing conceptual understanding.

Challenges: There is little literature on misconceptions in physiology. As we worked with physiology faculty it has become apparent that many faculty do not initially understand what we mean by misconceptions and this has led to interesting and productive discussions about student understanding and persistence of misconceptions and possible ways to assess and address these. Faculty have been very interested in this aspect of the work and these challenges have led to several faculty workshops on homeostasis misconceptions for Spring 2012.

28
PI: Dennis Minchella
Institution: Purdue University
Project Title: An Adaptation of a Research-Based Laboratory Model to the Life Sciences
Project Number: 0941921
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The primary goals of this project are for students to engage in the process of science by working in teams to ask questions, design experiments, gather and
interpret data, and communicate their findings. Additionally, we want to improve the students’ critical thinking skills. With the achievement of these goals we hope to increase student enthusiasm for science.

**Methods & Strategies:** We have collaborated with research faculty to develop and implement 2 research-based introductory Biology lab classes. Students learn basic lab techniques while engaging in authentic research in these classes. We are working to develop a third class to expand the offerings to the incoming Biology majors and have implemented a class at a regional Purdue campus.

**Evaluation Methods & Results:** Formative and summative assessments are used to evaluate student performance while in the class including lab reports in scientific paper format, weekly pre-lab quizzes, and informal presentations and formal poster presentations. Pre/post attitudinal surveys given to students in our classes and the standard lab class show that students’ interest and confidence in their ability in science increases significantly after our class and is significantly higher compared to students not in the class. We have seen significant gains in critical thinking as measured by the Critical thinking Assessment Test (CAT) over the course of a single semester. Longitudinal tracking of students will allow us to see the impact our class has had on their performance in future classes, interest in research, and persistence in the biology major.

**Dissemination:** One of our lab classes has been successfully implemented on a regional Purdue campus. We have published 2 manuscripts and presented 4 posters at national meetings describing the structure and content of our classes to facilitate adoption of the classes by others. We are currently expanding the number of these types of classes both at the introductory and upper division undergraduate levels. We are also exploring national networks such as CUREnet to share ideas and experiences with others involved in research-based lab classes.

**Impact:** The impact that this project has had on students has been positive and we have been successful in achieving our goals for them based on gains in the classroom, from survey results and CAT gains. Each of the classes has generated research-quality data for the collaborating research faculty. Some of the data have resulted in a research publication with the students as authors. The success of our project has been recognized nationally and within our department with several faculty members approaching us with ideas for future research-based classes.

**Challenges:** An unexpected challenge in this project has been that we need to reassure the students that they know enough to ask questions and dive into their research projects after 6-7 weeks. Similarly, they are sometimes hesitant to design their own experiments for fear of doing it wrong and having the results not support their hypotheses. We have explained to them that in research you can’t wait until you think you know everything about a topic before formulating hypotheses and experiments to test them. Further, as long as the experiments are designed carefully, whether the results support the hypothesis or not is interesting and not right or wrong.

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**29**

**PI:** Philip Myers  
**Institution:** University of Michigan Museum of Zoology  
**Project Title:** Discovering Patterns in the Natural World Through Student Inquiry  
**Project Number:** 1122742  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Our goal is to improve undergraduate education in organismal biology and ecology by designing inquiry-based activities that involve students querying a large database of natural history, implementing the activities in the classes of 22 instructors at a variety of 2 and 4 year colleges and universities, and testing their effectiveness at improving student learning.

**Methods & Strategies:** We are working with participating faculty to design and incorporate inquiry-based activities into their individual curricula, improve our query tool (animaldiversity.org/q), expand our natural history database, and assess effectiveness. We focus on 4 kinds of courses: introductory biology, mammalogy, ecology, and a group of natural history-based courses.

**Evaluation Methods & Results:** We are assessing student learning outcomes and usability of the query tool through pre- and post-implementation surveys focused on the inquiry process. Our first semester of data collection (winter 2012) is almost complete. The study is quasi-experimental with intact (non-randomized) classroom groups at each participating university. Some observational usability testing will be conducted with a sub-sample of students.

**Dissemination:** In fall 2011 we held 3 training workshops for 17 faculty participants from 16 institutions. We also participated in a meeting of national science synthesis centers (NCEAS, NesCENT, NEON, NIMBioS, etc.) where we shared our work on data querying. Our abstract has been accepted to the 2012 5th MERLOT/SloanC symposium for emerging technologies.

**Impact:** It is still too early for us to have concrete examples of impacts. Over the next two years, we hope to give students the experience of doing authentic scientific inquiry; improve student learning in key areas of evolutionary biology, ecology, and conservation biology; and change student attitudes about the nature and effectiveness of science generally. We also expect to expose faculty to methods and resources that involve students in active, inquiry-based learning, to produce a well-tested set of activities that can be incorporated into classes, and to provide
increasingly powerful tools for querying our database and others.

**Challenges:** The logistical challenges of bringing together faculty from around the country were daunting, but we were successful and these workshops were extremely productive. We proposed using our query tool (animaldiversity.org/q) to access data in other natural history databases. This has proven a significant challenge because other databases lack the necessary structure for querying. Encyclopedia Of Life, a significant partner, has delayed implementing structure in their database for a further two years. ADW is investigating other ways to provide students and faculty to additional data assets, including spreadsheet uploads and providing access to other data repositories and authentic inquiry projects.

**30**

**PI:** Pete Nelson  
**Institution:** Benedictine University  
**Project Title:** Understanding Biophysics Using Microsoft Excel  
**Project Number:** 0836833  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** There is a growing movement within biology to transform the undergraduate curriculum. This project supports that transformation, by providing a series of modules with instructor guides. The modules engage students in discovery-based activities to introduce them to the process of scientific modeling and validation in biophysics and physiology. The goal is for students to perceive biology as an evidence-based science with testable hypotheses that are supported by experimental data.

**Methods & Strategies:** The modules are a self-contained series of self-study guides for undergraduates (both with and without calculus). The modules are designed so that students can complete them without any additional assistance in a blank Excel spreadsheet, making them suitable for use as stand-alone homework assignments, biophysics computer labs, or for a complete discovery-based active-learning course. Each module also has an accompanying Instructor Guide, providing suggestions for group class discussion topics and in-class (group) activities.

**Evaluation Methods & Results:** The modules are being formatively evaluated during their development by assigning them to individual students for independent study (without any prior explanation), followed by informal interviews and subsequent improvement of the module. The modules have also been trialed as biophysics computer labs in my classroom with direct observation of student reaction to the material. A SALG survey instrument has been developed and is being used to assess student learning gains. In a recent SALG survey students were asked to assess how ideas from this class relate to real scientific research and 81% reported 5: great gain. Module 4 has now been formally peer reviewed by an AAMC panel and Modules 1 and 2 have been peer reviewed by the Archive Board of the American Physiological Society (APS).

**Dissemination:** I have also presented at many conferences in biophysics, physics and physiology. A shortened version of Module 4 was published as part of AAMC’s MedEdPORTAL uScience Inaugural Collection. Modules 1 and 2 are now posted at the APSArchive.org portal and Module 1 was featured on the front page in November 2011 and is currently a featured 'Inquiry-Based K-12 Science' resource March/April 2012. These materials are due to be published by Cambridge University Press. For more information see http://circle4.com/biophysics.

**Impact:** My biophysics class has been spontaneously transformed into a form of inverted classroom. Students are required to electronically submit draft answers to modules before class. In class we have group discussions of difficulties that students are having, but often students just work on finalizing their answers and simulation spreadsheets during class time. The broader impact of this project is that it exposes a wide range of undergraduates (both with and without calculus) to the scientific process of model development and validation. The marble game introduced in Module 1 provides a realistic conceptual framework for understanding a wide range of molecular transport processes in physiology. These transport phenomena are so fundamental that 'Transport Processes' was ranked as the second most important topic in pre-medical education (after ‘Nucleic Acids’) in a recent survey conducted by the AAMC. In Module 2 students are taught the basics of algorithm development. This is a foundational skill for the present project, but also has benefited students subsequently taking other quantitative courses such as bioinformatics and genomics. I am currently developing a reform for introductory physics I and II for life science majors based on this approach. It is hoped that the modules will become a resource for the growing movement to transform undergraduate biology.

**Challenges:** The modules are aimed at a wide audience - from physical science majors to pre-meds. This presents challenges when marketing them to instructors. The pitch for students without calculus (typically biology and physiology students) is that these materials are developed for students without calculus. The pitch for students with calculus backgrounds (biochemistry and molecular biology majors, physical science and (biomedical) engineering majors) is that the materials introduce advanced calculus-based materials, such as the diffusion equation with embedded source or sink terms, in a non-traditional manner that allows PDE’s to be introduced without discussing Fourier analysis. A major challenge that I foresee is finding instructors willing to try something new so that these materials can be thoroughly evaluated.
31
Pl: Clare O’Connor
Institution: Boston College
Project Title: Pathways Over Time: A Research Project for the Introductory Biology Laboratory
Project Number: 0114028
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The overall goal is to introduce a functional genomics research project into a multi-section introductory laboratory class in molecular cell biology. We are developing both student and instructor handbooks for the course, a data-sharing site using open source code and a graduate teaching assistant training program that incorporates the principles of scientific teaching.

Methods & Strategies: The course uses deletion constructs and overexpression plasmids generated by the yeast genome project as tester strains for student investigations. Students work in teams to design experiments addressing the functional conservation of proteins involved in methionine synthesis. Students use the primary literature and online databases to design hypotheses and interpret experimental results.

Evaluation Methods & Results: A variety of evaluation methods are used to assess student learning and project goals. Notebook assignments and pre-lab quizzes are used for each laboratory session. Students submit a series of lab reports, culminating in a final research paper. Student teams make oral presentations throughout the semester and present a poster at the end of the semester. Students also prepare an individual gene review that incorporates database and literature assignments. A practical exam and two written exams also assess student learning. We are working with collaborators in the Lynch School of Education to develop observation and interview protocols for assessing the effectiveness of the teaching assistant training program, as well as student teamwork.

Dissemination: Our project is part of the NSF-funded CUREnet RCN, and we are working with colleagues in neighboring institutions to develop a TA training program that incorporates scientific teaching. We have posted course materials on a website and deposited the lab manual with the e-Scholarship archive at Boston College. Publications in scientific and educational journals will further disseminate the project results.

Impact: The course has allowed ~300 undergraduate students each year to participate in a research project that is generating publishable results. The majority of students who enroll in the class are biology or biochemistry majors, but a significant number are premedical students from non-science departments. The course has been enthusiastically received by the faculty, who are increasingly requiring the course as a prerequisite for other coursework. The project has also sparked faculty interest in offering other advanced laboratory courses that incorporate research projects. The lab manual and some reagents have been shared with faculty at other institutions who are interested in working with us on the project.

Challenges: Our greatest challenge is ensuring that students enrolled in different sections of the course obtain the same quality of experience. To address that challenge, multiple sections of the course meet for short lectures with the course faculty at the beginning of each week, and we are expanding our TA training program. Another challenge is the limited time available in a semester to bring novice students to the point where they are able to produce publication-quality results. We are addressing this challenge with the development of a data-sharing site. At the end of each semester, we evaluate the results of the preceding semester and do some regrouping of topics for the next semester to maximize efficiency.

32
Pl: Mark Pauley
Institution: University of Nebraska at Omaha
Project Title: Integrating Bioinformatics into the Life Sciences
Phase 2
Project Number: 1122971
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The long-term goal of our project is to fully integrate bioinformatics into the biology curriculum at three diverse institutions and to disseminate the material developed through textbooks and the online resources of publishers.

Methods & Strategies: The primary objective of our project is to develop, field-test and assess a collection of vertically-integrated bioinformatics-focused laboratories and curated data sets that are fully relevant to fundamental biology concepts and that can be easily adopted and adapted to meet a variety of curricular goals.

Evaluation Methods & Results: The evaluation process for the project will include both formative and summative assessments focused directly on examining the development and effectiveness of the bioinformatics-focused laboratories. Three key data collection strategies will be used: 1) field-testing data from student pretests and posttests; 2) student focus groups; and 3) external expert reviews of the laboratories. Among other things, the evaluation process will document whether the laboratories are being developed effectively and whether they are contributing to student understanding of bioinformatics concepts.

Dissemination: We have commitments from faculty across the country to pilot laboratories developed as part of this project. Additional dissemination will occur through the project website, by publication and by presentation at conferences and
ultimately, through incorporation into textbooks and website resources.

**Impact:** The project is currently in its first year and within the initial development phase. As a large number of students take biology courses at all three participating institutions, our project will impact a large number of both students and instructors. We anticipate reaching an even larger audience as faculty across the country pilot laboratories developed as part of the project and as our material is incorporated into textbooks and online resources.

**Challenges:** Although obtaining 'real-word' student-friendly data sets for the laboratories is challenging, the project team is working together to address this problem. In addition, the project PI has recruited students in the B.S. in Bioinformatics program at UNO to help with this. Another challenge that the project team has faced has been getting senior personnel together when teaching schedules are so different among the partner institutions. To address this problem, the team has been meeting on designated Saturdays and communicating routinely via e-mail, phone and via the web.

**33**

PI: Anne Rosenwald  
**Institution:** Georgetown University  
**Project Title:** Generating a Community for Undergraduate Research Through the Use of Comparative Microbial Genomics  
**Project Number:** 1123016  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise  

**Goals & Intended Outcomes:**  
1. Develop a website (Genome Solver) for students, faculty and experts to share research and curricula using data from the Human Microbiome Project (HMP);  
2. Develop faculty expertise via workshops on tools available to study the HMP.

**Methods & Strategies:**  
1. Website development (essentially complete - up and running, but continued improvements - March 2012)  
2. Faculty expertise by small group workshops to discuss HMP, the tools available to study, and best practices in pedagogy around this topic

**Evaluation Methods & Results:**  
Project is just getting underway but our plans include:  
1. Website usage - Google Analytics;  
2. Value of workshop - faculty feedback at start of workshop, at end of workshop, and upon continued reflection;  
3. Impact on student learning - pre/postquiz to assess learning;  

**Dissemination:** Advertisement of workshops - we have more applicants than we can accommodate; Paper to be presented at International Conference on Computer Science - June 2012, Omaha; Poster to be presented at Amer Soc for Microbiology Mtg - June 2012, San Francisco; Two short presentations at HHMI workshops - Feb 2012 and June 2012. Plans for research and science ed papers in future.

**Impact:** Expect our students to benefit by having active, open-ended learning opportunities that are authentic research projects. Expect that other faculty as we disseminate our thoughts and gather theirs will also find this a valuable approach for getting research experiences in the classroom.

**Challenges:** The website took longer to develop than we originally anticipated but it is up and running as of March 2012 - though we continue to add additional functionalities. We originally anticipated the first workshop to be held January 2012, but since the post-doc working on the project wasn’t hired until November 2011, this seemed unreasonably soon. We therefore decided to instead have two workshops in Summer 2012 - one in June and one in July. We plan to continue to have two workshops a year subsequently - one in January and one in the summer.

**34**

PI: James Smith  
**Institution:** Michigan State University  
**Project Title:** Integrative Case Studies in Evolution Education  
**Project Number:** 1043876  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** We are developing six online case studies in evolution education that integrate biological principles across sub-disciplines. These case studies are being piloted in both introductory and upper-division biology courses at Michigan State University. We have developed, validated and are using a test instrument to assess the effectiveness of the case studies as a tool for teaching evolutionary principles.

**Methods & Strategies:** We hired a post-doctoral associate, Peter White, to take the lead on this project. Along with the PIs, White has designed and validated the assessment tool via analysis of free responses to questions as well as interpersonal interviews. The assessment tool is being used in a pre-/post-test design in piloted trials. We are also conducting professional development activities with our collaborators to develop both content and pedagogical expertise.

**Evaluation Methods & Results:** Our external project evaluator, Craig Nelson, has worked with us to design the assessment tool and has provided advice on various aspects of the implementation of our research plan. At the end of this semester (spring 2012), collected data will be summarized and
sent to him for review. Nelson will be coming to Michigan State for a site visit later in 2012.

**Dissemination:** We have disseminated our case studies (beta versions) to our collaborators (the pilots). In summer 2012, we will present the case studies at two on-campus events, one involving high school teachers. We will also be presenting the project and our year one results at the Introductory Biology Project Summer Conference, the First Congress in Evolutionary Biology, and the Society for the Advancement of Biology Education Research annual meeting.

**Impact:** We are just reaching the end of our first full-fledged pilot semester and the first major data set from the pilot courses in forthcoming in two weeks. Nonetheless, we have already noticed some impacts of our work. I, personally, have changed my Introductory Biology curriculum to focus on what I consider to be concepts that are ‘more important’ for understanding evolution more broadly. We’ll see if the student data bear this out. I have also generated interest in the case study materials from both on-campus and off-campus colleagues. We anticipate that our work will lead to deeper student understanding of evolutionary concepts, in particular the connections between mutations at the DNA level, the resulting phenotypic differences, and how natural selection operates to favor one phenotype (and hence one molecular form) over the other.

**Challenges:** The two main challenges have been the reluctance/ inability of some cooperators to follow through on their promises of collaboration. People simply can’t find time to implement the materials in their own classes. In addition, our post-doc got a job offer early in the project. We’ve been fighting to keep him onboard and involved in the project to allow us to bring it to completion.

35

**PI:** Kathrin Stanger-Hall  
**Institution:** University of Georgia  
**Project Title:** Animated Case Studies In Science (ACISIS): Transforming Student Learning of Biology  
**Project Number:** 1044370  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** The goal of this study is to evaluate whether inquiry-based 3D animated case studies help introductory biology students learn three fundamental biological processes: diffusion, osmosis and filtration (compared to learning with still images embedded in the same case studies).

**Methods & Strategies:** The three case studies (on the three processes) are implemented as a supervised homework activity in a large introductory biology class (400 students). Students earn class credit for both completion and answer quality. The different case study versions are implemented in different semesters.

**Evaluation Methods & Results:** Student learning is assessed by pre- and post-case assessments (short-term) and through questions on the final exam (long-term). In addition, students evaluate each case study with respect to their perceived individual engagement in the case, ease of use of the case and their learning gains. Outcomes will be compared between non-interactive case studies (with still images) and their inquiry-based 3D animated versions.

**Dissemination:** None completed. Research results comparing the outcomes from the different case study versions will be published. The final (improved) online cases will be commercially available for instructors and their students at an online site.

**Impact:** We just implemented the non-interactive cases (still images), and data have not been analyzed yet. Oral feedback from students indicates interest in the cases and engagement with the case studies.

**Challenges:** It was more difficult than expected to upgrade the existing animated 3D case studies from high school to college level (due to the complex gaming environment they were built it). I have obtained additional funding to do that, and we will be finished in time for the planned implementation. In the meantime we are collecting data on the case study versions with still images.

36

**PI:** Eleanor Sterling  
**Institution:** American Museum of Natural History  
**Project Title:** Developing and Assessing Process Skills in Conservation Biology and Other Integrative Fields  
**Project Number:** 0942789  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** The goals are to: 1) create and validate a set of instructional materials designed to develop and assess process skills important in conservation biology and other integrative fields, and 2) pilot developed teaching and assessment materials in diverse classroom settings. We expect to increase our understanding of how to promote data analysis, critical thinking, and oral communication skills in students.

**Methods & Strategies:** After creation and validation of instructional materials designed to develop and assess critical thinking, data analysis, and oral communication, we are piloting the materials in a diverse group of academic institutions across the US. Each faculty participant implements a set of
Instructional materials for a particular skill during two separate semesters of the same course.

**Evaluation Methods & Results:** Our evaluation plan includes formative and summative evaluation activities and the application of diverse tools, both quantitative and qualitative. Project personnel are undertaking ongoing project evaluation with input from project advisers. An evaluation specialist will evaluate the project at mid-point and at its conclusion.

**Dissemination:** We are working with 18 faculty members from diverse academic institutions across the US, including Puerto Rico and the Virgin Islands. In the future, we will make instructional units available to a broader audience of faculty members and conservation trainers through the NCEP website (ncep.amnh.org)

**Impact:** Through this project, faculty members participated collaboratively in the development of teaching and assessment materials. By implementing these materials in their courses, faculty participants are not only learning about their students' development of process skills, they are also learning about their own teaching practices. In terms of students, this project intends to increase students' proficiency with process skills important in conservation biology. They will do this through a series of exercises and classroom discussion as well as through self-reflection about the targeted skill.

**Challenges:** Participating faculty found our original experimental design of teaching and assessing more than one skill at a time to be logistically challenging. We adjusted the design to implement teaching and assessment materials for only one skill at a time. This modification did not change the overall goal of the project. Also, faculty members' participation in the development and validation of the teaching materials was less than expected. Project personnel spent more time than planned working on these tasks.

**Methods & Strategies:** Hold workshops for high school, community college, and college teachers to have them experience the processes and learn how the techniques can be used. Engage undergraduates in the process of evaluating gene expression and comparative genomic studies using our equipment, and build new equipment.

**Evaluation Methods & Results:** For evaluating the effectiveness of pedagogical applications by workshop attendees, we have pre- and post-surveys measuring content and attitude changes. For the production of pedagogical materials, we maintain a web site where these are posted. For the learning experiences of students involved in the engineering project, other research experiences, and serving as teaching assistants in the workshop, we have formal and informal interviews.

**Dissemination:** We presented the first year's work at the national ASM and CUE meetings in 2011. We are preparing a publication for the ASM education journal at their request. We plan to publish in Cell Biology Education after the current semester is finished and all results are tabulated. This will include the first array designed by an interdisciplinary team of students working with the engineering student team.

**Impact:** We have trained 20 faculty in the two years of workshops. Reported numbers of students impacted is over 700. The activities range from a module in a microbiology lecture course to independent research by a team of two students. Undergraduates at JMU have been very positively impacted by the opportunity to build the arrayer, be involved in designing an array, and in serving as teaching assistants. The impacts are not easily measured quantitatively at this point, but the testimonials are very positive. Fifteen students have been involved over the two year period. The PIs on this grant have been positively impacted by opportunities for relationship building and new research collaborations.

**Challenges:** The procedure for obtaining data from microarray technology is technically challenging and the success rate is fairly low. We are looking at some simpler slides (fewer probes, hand-spotted) as a way to increase the success of short term experiments that will be successful. The workshop was challenging only because we had so many interested people. The array building project has been challenging, but that is not really a negative, as this project has been extremely effective for the engineering curricular goals.

**37**

**PI:** Stephanie Stockwell  
**Institution:** James Madison University  
**Project Title:** CCLI: Establishing a Microarray Teaching and Learning Center in the Shenandoah Valley in Support of Science Education  
**Project Number:** 0942583  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Use microarray technology as a context for teaching molecular genetics; train faculty who will develop and use pedagogical and laboratory experiences to accomplish this; obtain a microarray reader and utilize at the regional level; have engineering undergraduate build an arrayer to make custom slides.

**38**

**PI:** Robert Tallitsch  
**Institution:** Augustana College  
**Project Title:** The Effects of Computer-assisted Instruction in Teaching Human Anatomy: An Experimental Study  
**Project Number:** 0834873  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education
**Goals & Intended Outcomes:**  
**Goal:** Evaluate whether or not computer-assisted instruction (CAI) enhances students' ability to interpret 3D structural relationships.

**Intended outcomes:** Test effect of CAI on students' ability to interpret 3D relationships, retention of material and interest levels in the class.

**Methods & Strategies:** Compare the effects of CAI on students' ability to interpret 3D relationships, retention of material and interest levels in the class between control (No CAI in year 1) and experimental (utilize CAI in years 2 and 3) years at two four-year colleges.

**Evaluation Methods & Results:**  
Students' abilities to (1) interpret 3D relationships (as measured by the Purdue Visual Rotation Test), and (2) retain course material (as measured by a Test of Essential Material) were significantly increased through the use of CAI. Students' interest in the class (as determined by survey results) was increased through the use of CAI, but not at a significant level, due to a 'ceiling effect.'

**Dissemination:** Results have been, and will be presented at national scientific meetings, and two articles are currently either in preparation or have been submitted. A TUES Phase 2 grant has been submitted to further this study. Additional presentations at regional and national meetings are planned.

**Impact:** The use of CAI resulted in positive outcomes regarding student learning and attitudes. If these data can be verified and expanded upon by the TUES Type 2 grant results these data will be utilized to encourage institutions to implement CAI in their teaching of Human Anatomy and Anatomy and Physiology Courses.

**Challenges:** No challenges.

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**Evaluation Methods & Results:** We employ mixed methods to evaluate our progress toward our aims. This includes in-person and online, open-ended and Likert scale data. Participants take online pre-assessments to gauge their pedagogical experiences, classroom methods, and attitudes toward scientific teaching. We track those responses in activity-embedded assessments and post-assessments.

**Dissemination:** CCB FEST is itself an effort to disseminate pedagogical innovations to the 400 biology faculty working in 23 community colleges in the San Francisco Bay Area. To date, over 100 biology faculty from all 23 campuses participated, as well as 15 graduate students who are aspiring community college instructors.

**Impact:** In total, CCB FEST has now provided over 3,000 participant hours of training in scientific teaching and involvement in professional learning communities to over 100 community college biology instructors form 23 different colleges, which will indirectly impact tens of thousands of community college students. In addition, CCB FEST activities have involved 15 biology graduate students who are aspiring community college biology instructors. We envision that this effort could grow into a national effort, complementary to the National Academies Summer Institute for Undergraduate Biology Teaching model.

**Challenges:** Ongoing challenges include serving the continued needs of the large and dynamic community college biology faculty community with limited financial resources, while additionally attempting to apply limited financial and human resources to collect data on student-level assessment outcomes across the diverse array of participating instructors' classrooms.

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**Goals & Intended Outcomes:** This project disseminates and assesses MathBench Biology Modules, which imbed quantitative approaches in the biology curriculum. Our ultimate goal is to refine the modules based on assessment data and create a faculty development framework to support wider dissemination.

**Methods & Strategies:** We have held faculty training workshops for individuals from 33 institutions differing in size, demographics, and other attributes. Faculty are implementing Mathbench at their home institutions and administering common assessment instruments that will enable us to gauge the impact of the modules.
**Evaluation Methods & Results:** We developed a test of quantitative skill, a survey of student attitudes, and a faculty implementation survey. The quantitative skills test and attitudes survey are administered before and after use of MathBench modules to measure the impact of the modules on students. The implementation survey is administered after faculty have implemented the modules (or one year after attending the faculty training workshop, whichever comes first) to help us to identify factors that facilitate or hinder adoption of MathBench, enabling us design strategies for effective broad dissemination.

**Dissemination:** We have held four training workshops, attended by 48 faculty members from 33 institutions. We have planned one more training workshop in conjunction with a national teaching conference, but have yet to identify the venue. We have published one paper and are preparing two more for publication this year.

**Impact:** Students who have used MathBench have increased quantitative skills and appreciation for the role of mathematics in the biological sciences. The MathBench project is now a central component of a larger program-level initiative to enhance quantitative training for biology students on our campus. We have recently partnered with a group of Australian institutions studying how quantitative skills are imbedded and assessed in undergraduate science curricula and will give an invited talk on this subject at their 2012 international symposium. We continue to develop a national network of MathBench users.

**Challenges:** It has been relatively easy to recruit faculty for training workshops, but not all participants have implemented MathBench in their courses. Among those adopting MathBench, not all are participating in assessment activities. Some faculty have been reluctant to administer the quantitative skill assessment to students because of its rigor. We are working to maintain communication with faculty and provide the support necessary for them to participate fully in implementation and assessment. Our implementation survey will provide additional insight into factors that facilitate or hinder their participation.

**41**

**PI:** Lillian Tong  
**Institution:** University of Wisconsin-Madison  
**Project Title:** Disseminating Scientific Teaching  
**Project Number:** 0817545  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** The goals of the program are (1) to augment postdoc research training with skills and experience in teaching and mentoring and (2) to train emerging leaders in education reform, thereby amplifying the impact of their knowledge.

**Methods & Strategies:** After a year-long teaching professional development program, postdocs applied to the Scientific Teaching Postdoc Program (STPP) to learn to facilitate, lead, and evaluate their own faculty development workshops about scientific teaching. Postdocs then designed and led their own workshops.

**Evaluation Methods & Results:** We measured impact on the postdocs and the participants in the workshops they led, using an adapted version of Connolly and Millar's workshop impact model (2006). Three cohorts of 19 postdocs at two universities completed the training and led 18 workshops for ~450 participants, who reported the experience was valuable (99%) and who reported learning gains in scientific teaching, active learning, assessment, and diversity. Impact on postdocs was measured through interviews, surveys, and observations.

**Dissemination:** The 19 postdoc-led workshops about scientific teaching were the primary dissemination activity. Program staff also presented more than 10 workshops and posters about (a) project outcomes, (b) how to do similar program evaluation, (c) how to facilitate groups, and (d) how to lead scientific teaching events.

**Impact:** The project had impact at our own institution (UW-Madison) through postdoc-led workshops about scientific teaching and through development and leadership of an annual postdoc conference, and successful parts of the program were integrated into a new HHMI-funded teaching postdoc program at UW. National impact at universities and professional societies included the institutions or conferences where the postdocs led workshops, at the colleges and universities where they are now employed, and via the National Academies Summer Institute (through the faculty attendees and their home institutions).

**Challenges:** During the award period, we transitioned PIs twice. First, upon PI Handelsman’s departure to Yale University, we transitioned to Balser; within the year, Balser departed for the University of Florida, and the PI transitioned to Tong. Despite the changes in PI-ship, the program moved forward smoothly and efficiently, thanks to co-PI Miller’s leadership. However, communication from NSF to the PIs did not follow, causing some confusion.

**42**

**PI:** Eric Triplett  
**Institution:** University of Florida  
**Project Title:** Sequencing Gators: Building a Genome Science Curriculum at the University of Florida and Beyond  
**Project Number:** 0920151  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Our goal is the improve the undergraduate microbiology curriculum at the University of Florida. The project integrates genomics and bioinformatics
throughout the levels of the undergraduate curriculum to introduce more students to high-throughput era of biological research. We are translating all of these efforts to distance education and will expand the reach of these improvements with community college partners.

**Methods & Strategies:** To increase exposure and experience with genomics, we have developed six new courses that reach all different levels of the undergraduate curriculum. Some of the courses involve original research projects in genomics.

**Evaluation Methods & Results:** Assessment includes a pre-then post-test design using online-delivered survey questionnaires. Each one of the instruments included items to measure Knowledge, Skills, and Aspirations of students regarding genomic science within the specific context of each course. Students completing these courses showed positive outcomes. Students increased their understanding of the specific subject matter of the course and felt more confident to perform research-associated tasks. Their interest in the different topics covered by the courses was also enhanced, and some of them even wish to pursue a related career.

**Dissemination:** Data generated from two of the courses has led to three peer-reviewed research publications with students listed as co-authors as well as two peer-reviewed teaching and learning publications. Work from this project has been presented at three meetings to date (two national, one regional) and is scheduled to be presented at a national meeting in June 2012.

**Impact:** We are collaborating with the largest minority institution in the country, Miami Dade College in Fl, to build a pipeline so that students earning their A.A. can continue directly into their BS degree from UF and then their Ph.D. This pipeline will lead to an increase in diversity in the life sciences. Many of these students are non-traditional students who have families, full-time jobs, and are experience economic difficulties. The distance education program allows them the opportunities to move forward academically and professionally without relocating to Gainesville.

**Challenges:** One unexpected challenge is the low retention of students in the distance education 2 + 2 program established with Miami Dade College. We are developing ways to determine why retention is low and how to increase retention.

**Goals & Intended Outcomes:** We are creating an on-line, valid and reliable multiple choice test to assess undergraduate life science major’s mastery of the science process and reasoning skills of experimental design, data analysis, graphing, and science communication. The diagnostic test, SPARST, can be used by faculty and departments to assess student progress though the major as well as to assess the effectiveness of current and transformed pedagogy.

**Methods & Strategies:** We have surveyed faculty to identify learning outcomes for the four science skills, written questions to address each outcome, vetted the questions with expert faculty to establish content validity, used student focus group to determine readability of the test, and will beta test SPARST at eight different institutions from community colleges to R1s.

**Evaluation Methods & Results:** We will perform Rasch Item Analysis on data collected to determine internal validity and reliability of test items. Rasch analysis will also indicate which questions need to be modified in future beta testing of SPARST.

**Dissemination:**
- University of Washington Biology Education Research Group meeting.
- Biology Leadership Conference in South Carolina.
- Society for the Advancement of Biology Education Research (SABER) national meeting in 2012.
- Experimental Biology-American Physiology Society-Teaching Section Symposium in 2013

**Impact:** Though we have piloted the experimental design component of SPARST, we will not pilot the complete SPARST until autumn 2012. However, we have discovered that an unexpected impact of the project is the increased awareness and deeper understanding of how to assess science process that the faculty on our advisory boards gain by generating and vetting the questions to be used on SPARST.

**Challenges:** It has been a challenge to find times at which the eight advisory board faculty can meet. We have decided to break the advisory board into a East Coast and West Coast contingent and meet with them separately and sequentially as well as employ Skype and other technology to facilitate exchange of ideas.

**43**
**PI:** Mary Pat Wenderoth
**Institution:** University of Washington
**Project Title:** SPARST: Assessing the Process of Science
**Project Number:** 1043283
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Assessing Student Achievement

**44**
**PI:** Michelle Withers
**Institution:** West Virginia University
**Project Title:** The Pursuit of Excellence: Transforming Undergraduate Science Education through Evidence-Based Practice
**Project Number:** 0919800
**Type:** Phase 2/Type 2 - Expansion
**Focus:** Developing Faculty Expertise
**Goals & Intended Outcomes**: The goal is to transform regional undergraduate STEM education in science and math by training present and future faculty in scientific teaching. Participants will create and implement scientific teaching materials/strategies in their undergraduate STEM classrooms.

**Methods & Strategies**: Offer 4 regional summer institutes modeled after the National Academies Summer Institute and 4 follow-up alumni meetings. Evaluate changes in knowledge, attitudes and behaviors of participants following participation in these events. Create a website to facilitate networking and dissemination.

**Evaluation Methods & Results**: Post-perception, interviews and follow-up surveys will be used to assess changes in knowledge, attitudes and behaviors surrounding teaching. RTOP and timing analysis of teaching videos will give off evidence of changes in teaching behaviors.

**Dissemination**: Offered 2 summer institutes and one follow-up alumni meeting. Shared information on regional adaptations and success with NASI who used this information as motivation to create 6 more regional institutes. Created a Facebook page and will create a wiki for networking and dissemination.

**Impact**: Participants report through post-s surveys that the institute is extremely effective in increasing knowledge and awareness of scientific teaching and providing training for implementation of scientific teaching strategies. Follow-up surveys show that majority of participants implement strategies.

**Challenges**: Recruiting is challenging. We have used educational listservs and educational organization affiliations to do targeted advertising and recruitment to overcome this challenge. Follow-up meeting attendance was low for the first meeting (2011). We are attempting to use web-assisted conferencing to include more participants for the 2012 follow-up meeting.

**Chemistry**

**46**

**PI**: Nathan Barrows

**Institution**: Grand Valley State University

**Project Title**: Collaborative Research: Advancing Chemistry by Enhancing Learning in the Laboratory (ACELL)

**Project Number**: 1021973

**Type**: Phase 2/Type 2 - Expansion

**Focus**: Developing Faculty Expertise

**Goals & Intended Outcomes**: The ACELL project seeks to provide professional development of chemistry faculty by
expanding their understanding of research-based pedagogies and encouraging their involvement in developing a community of practice focused on improving laboratory instruction.

**Methods & Strategies:** The project's set piece is a four-day workshop that introduces 24 faculty-student teams to discovery and guided-inquiry pedagogies as well as the science writing heuristic. Participants will complete, discuss, and critique both inquiry-based and faculty-submitted labs. After the workshop, participants will engage in action research projects related to laboratory-based learning.

**Evaluation Methods & Results:** Participants' perspectives of laboratory instruction will be assessed before and after the workshop via several instruments. Semi-structured phone interviews will be conducted with faculty and student participants before and after the workshop to ascertain their individual contexts/circumstances and to triangulate their survey responses. Changes in the content knowledge of student participants will be documented with content assessments developed for each faculty-submitted laboratory. These will subsequently used in the participants' action research projects at their home universities.

**Dissemination:** The first presentation related to the ACCELL project was given by MaryKay Orgill at the 243rd ACS National Meeting (3/27/2012). Future presentations at national meetings and journal submissions with student coauthors are anticipated.

**Impact:** It is hoped that the disseminated findings from the ACCELL project will prompt chemistry laboratory instructors and coordinators to implement more inquiry-oriented pedagogies at their universities. The instructional materials developed during the participants' action research projects will augment the pool of validated laboratory activities available to chemistry instructors worldwide.

**Challenges:** No unexpected challenges have occurred to date.

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**47**

**PI:** Nicholas Benfaremo  
**Institution:** Saint Joseph's College of Maine  
**Project Title:** Integration of Spectroscopic Techniques Across the Undergraduate Curriculum  
**Project Number:** 0942192  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** The three main goals of the project are: to make the laboratory experience more relevant to the students, to make it more contemporary, and to make it more integrated and collaborative.

**Methods & Strategies:** We are using spectroscopy (UV-Vis, IR, and NMR) as a unifying common link between courses and over the students' career. We are having students in different sections and different courses collaborate.

**Evaluation Methods & Results:** In our first year, evaluation method have been was a Likert-type questionnaire. In our second year, we replaced our original assessment with a much more comprehensive Spectroscopy Skills assessment. We also met with an outside consultant.

**Dissemination:** We have developed an experiment which we are preparing to submit for publication. In addition, we will soon set up a website to transfer our activities and results from an internal site to an open site.

**Impact:** The project has motivated the students and given them much more confidence in their work. The faculty is using spectroscopy and instrumentation more in their courses and the institution (Board) has made a commitment to upgrade the science facilities. It also seems that more students are interested in minoring or majoring in Chemistry.

**Challenges:** The biggest challenge has been in getting faculty to assist in the data collection. The most successful method for moving the project forwards has been for the PI's to take a much more active role and teach more labs themselves. We also found that our assessment method was lacking and developed a new assessment instrument that is much more objective.

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**48**

**PI:** Emily Borda  
**Institution:** Western Washington University  
**Project Title:** Chemistry for the Informed Citizen (CIC)  
**Project Number:** 0737551  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** To adapt a recently developed constructivist chemistry curriculum for preservice elementary teachers to chemistry courses for non-science majors at 3 different institutions. Intended outcomes include increased student understanding of chemistry concepts and the nature of science.

**Methods & Strategies:** We have been using an iterative curriculum adaptation/revision/data collection cycle in which student learning data informs revision and adaptation of the curriculum to different contexts. Instructors meet regularly to discuss videos of their teaching in a 'video club' format.

**Evaluation Methods & Results:** We have been administering field-tested conceptual chemistry and nature of science questionnaires to students at the beginning and end of each course using the constructivist curriculum. We have also been conducting live observations of pedagogy in each course using a
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field-tested protocol. Data suggest increased quality of instruction and increased student understanding as the project matures. Few claims can so far be made with respect to student understanding of the nature of science since the instrument measuring this was recently changed.

**Dissemination:** Oral and poster presentations have been given at meetings of organizations for science education (NARST, ASTE) and chemistry (ACS). A manuscript comparing 3 CIC courses to a traditional course is currently under review for inclusion in an edited book about research in undergraduate education.

**Impact:** Since the beginning of this project, over 1200 students have completed a course that used the CIC curriculum and have exhibited marked learning gains compared to traditionally taught students. Project personnel have gained a greater awareness of student difficulties and misconceptions and have revised and added activities to the curriculum to meet these. Finally, personnel have gained a greater awareness of effective pedagogical techniques through video club meetings and have increasingly implemented these in their classrooms.

**Challenges:** We did not originally expect to spend so much time revising the CIC curriculum, but as we have encountered more student misconceptions and difficulties have felt the need to add and improve activities. We have applied for no-cost extensions and have reallocated funds from other budget categories to allow for more summer work time to meet this challenge. Also, we have been surprised by the negative reactions some students had to this curriculum and have developed activities to create an awareness of constructivist learning to mitigate these reactions somewhat.

**49**
**Pi:** Stephen Cessna
**Institution:** Eastern Mennonite University
**Project Title:** Promoting Learning Through Authentic and Relevant Research Experiences in Environmental Monitoring and Remediation Across Ten Chemistry and Biology Laboratory Courses
**Project Number:** 0837578
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** To introduce several multi-week integrated research projects on topics of environmental remediation to 10 undergraduate biology and chemistry courses. Through these experiences we expect increased learning of the nature of science, critical thinking skills, and skills in scientific communication.

**Methods & Strategies:** We are developing new teaching materials for several new open-ended research projects for traditional laboratory courses. Student develop research products (papers, posters, and oral presentations) in several courses. These products are assessed by a comprehensive rubric bank.

**Evaluation Methods & Results:** We are assessing learning with the SUSSI, a tested instrument for gauging student understanding of the nature of science and scientific inquiry. We are also measuring student learning through repeated use of similar rubrics, and student surveys and interviews. Student understanding of the nature of science improves, even after one semester, and continues to improve with reiterations (taking more courses that use these types of projects, or performing more than one project in one course.) Students and their teachers perceive an improvement in the scientific communication skills.

**Dissemination:** We have a paper in press in Chemistry Education Research and Practice, and two more papers in preparation for other biology and chemistry education journals. We will present our findings at three conferences in the coming year (including BCCE and ACS meetings). We have a webpage.

**Impact:** There has been an enhancement of learning, particularly of the nature of science understanding, and also in communication skills. Also, student generally report an appreciation for the project-based laboratories. The participating faculty have gained confidence in assigning longer term open-ended laboratory projects, and assessing the work from those projects in a manner that enhances learning. This CCLI project has also helped to enhance a ‘community of interdisciplinary and collaborative research’ within and between STEM departments.

**Challenges:** At first we were quite naive and assumed that making these changes to our curriculum would lead to increases in learning of the content matter (e.g. thermodynamic principles), analytical skills (e.g. instrumental skills, such as care and use of a spectrometer, and analyzing and using data appropriately for inference formation), laboratory safety and care, critical thinking skills, communication skills (e.g. writing research papers), and nature of science understanding. They might actually learn all of this, but we have learned that we really cannot assess all of that. We had to scale back.

**50**
**Pi:** Renee Cole
**Institution:** University of Iowa
**Project Title:** Collaborative Research: Exploring Student Understanding of Physical Chemistry
**Project Number:** 0816792
**Type:** Phase 2/Type 2 - Expansion
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** (1) To develop and adapt Toulmin analysis for use in chemistry classrooms to document the collective activity of a classroom community of learners. (2) To
use Toulmin analysis to describe student understanding of mathematical inscriptions and concepts used in Physical Chemistry.

**Methods & Strategies:** Video recordings of whole class and small group discussions were transcribed and then coded using Toulmin’s model. The argumentation logs were analyzed to identify shifts in reasoning and normative ideas as well as the development of sociochemical norms within the class.

**Evaluation Methods & Results:** Toulmin analysis is appropriate to investigate classroom discourse in chemistry. The creation and analysis of argumentation logs have provided insights into student understanding of physical chemistry and student ability to use mathematics in understanding physical chemistry. The evaluation of the methodology was done through the process of data analysis and peer review from external reviewers. The insights into student learning have been evaluated through peer review of the results.

**Dissemination:** There have been 13 conference presentations (including both chemistry and mathematics). A paper detailing the methodology has been published. A paper documenting the development of a sociochemical norm has been submitted for publication, and another manuscript is in preparation.

**Impact:** Two faculty members and one graduate student outside the project have requested and been trained to use Toulmin analysis in chemistry. Significant interest has been indicated by additional faculty who are also interested in using Toulmin analysis to either analyze student discourse or use it as a teaching tool to promote appropriate scientific discourse. Whenever this work is presented to chemistry faculty, there is significant interest in identifying additional ways to promote scientific argumentation in their classes.

**Challenges:** The project was funded as a Type I instead of the proposed Type II. This required the project to be scaled back in scale and scope. We also encountered challenges in employing consistent application of Toulmin analysis. This was overcome by regular meetings of the project team to develop a protocol for coding and a check for consistency of coding.

**51**

**PI:** David Collard  
**Institution:** Georgia Institute of Technology  
**Project Title:** Collaborative Research: Chemistry Coalitions, Workshops and Communities of Scholars  
**Project Number:** 1022796  
**Type:** Phase 3/Type 3 - Comprehensive  
**Focus:** Developing Faculty Expertise  

**Goals & Intended Outcomes:** The chemistry Collaborations, Workshops and Communities of Scholars program (cCWCS) supports workshops and other activities that address the enhancement of teaching through the dissemination of high-quality curriculum materials and pedagogies.

**Methods & Strategies:** cCWCS funds an annual series of 8-10 week-long workshops; advertises faculty-enhancement programs that are supported by other grants; provides access to an online application system; operates a small-grant program; and provides a template and support for STEM education websites.

**Evaluation Methods & Results:** cCWCS has an extensive and mature evaluation program. In addition to end-of-workshop surveys, participants complete follow-up evaluations to describe how they have used workshop materials in their own teaching. A series of pre- and post-workshop surveys of participants' students is underway. Outcomes include extensive adoption of workshop materials, new laboratory exercises, new courses, new degree programs, publications and conference presentations.

**Dissemination:** cCWCS strives to support STEM-education projects, especially those supported by other NSF TUES awards, in dissemination and outreach activities. cCWCS offers a suite of tools for advertising, accepting applicants, and development of online communities.

**Impact:** In addition to outcomes listed above, we have seen a number of workshop participants return in subsequent years as co-presenters, establish their own week-long workshops, and lead less-intensive dissemination and outreach activities (e.g., mini-workshops at BCCE, 2YC3). New small grant programs offer support to participants to adopt workshop activities in their own teaching and to engage in further dissemination activities.

**Challenges:** (i) cCWCS workshops are regularly oversubscribed. This led to the creation of a small grant program to support shorter, less-intensive dissemination programs to engage more instructors in faculty-enhancement activities. (ii) Many faculty members report that even small amounts of support for conference travel and curriculum innovation are not available for their own institution. Accordingly, we have instituted travel and small equipment grant programs (with 100% matching requirement).

**52**

**PI:** Linda Columbus  
**Institution:** University of Virginia  
**Project Title:** Known structure, unknown function: An undergraduate research curriculum  
**Project Number:** 1044858  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The goal is to design and implement a year-long research-based undergraduate
biochemistry laboratory. The results will improve undergraduate biochemistry education and provide the biochemical education community with a rigorous curriculum with proven results.

**Methods & Strategies:** We are using a research-based curriculum, group- and peer-led learning in the laboratory and inverted (flipped) lecture content, mini-lecture and demonstration videos, peer-based learning and interactive learning in the lecture.

**Evaluation Methods & Results:** We use SALG for student perceptions of learning gains and experience and we use pre- and post-course testing and well-designed rubrics for assessing learning gains. Student surveys overwhelmingly show that students felt that this course helped them become better independent thinkers, more skilled in scientific communication, and have more scientific knowledge overall than other laboratory-based courses had.

Prior to taking the course, the average for the 23 question knowledge survey was 52%; the results of the same survey administered post-course averaged 77% and showed tighter distribution of scores, highlighting significant learning gains.

**Dissemination:** We have designed and implemented a website with modular instruction material in separate resource area for students and instructors (password protected). When finalized, the website will be disseminated through mailings and collaboration with PUIs and universities.

**Impact:** Based on the results of our 4 point Likert survey, our students gained confidence in and a deeper understanding of biochemistry, both of which are key to developing the communication and critical thinking skills required for success in the field. The results of a test administered before and after the course showed significant learning gains in all areas, indicating that the inquiry-based environment in the first semester did not detract from the students learning.

**Challenges:** Challenges encountered in implementing this course were the lack of available resources in one location. We overcame this by creating video mini-lectures, writing the laboratory manual in-house, and supplementing the laboratory manual with additional resources, many posted on our BioLEd website.

**Goals & Intended Outcomes:** Development of a new general chemistry curriculum, using learning progressions for structure, function and energy.

**Methods & Strategies:** We are developing integrated text, interactive materials and assessments that provide students with core fundamental concepts of chemistry.

**Evaluation Methods & Results:** Students in the CLUE curriculum are being compared to a statistically equivalent group who are taking a traditional general chemistry course. We are using both qualitative and quantitative methods, developing and validating instruments, and using available instruments to compare achievement, and attitudes.

**Dissemination:** We have a publisher for the curriculum (Cengage) and the materials are undergoing initial review at the moment. All the materials are available on the CLUE website: http://besocratic.colorado.edu/CLUE-Chemistry/index.html. We are also recruiting volunteers to use the materials.

**Impact:** Students in the course have improved ability to construct Lewis structures and use them to predict properties of materials, compared to a similar cohort (effect size 0.6). Studies on ability to use and develop models, scientific arguments, energy interactions and acid base reactions are underway.

**Challenges:** Students in a new curriculum have expectations about what they should be learning, which may not have been what they needed to learn. We have been very explicit about the expected outcomes of the course.

**54**

**PI:** John Dwyer  
**Institution:** St. Catherine University  
**Project Title:** Project TUESPY: A Grant Proposal Preparation and Mentoring Program for Two-Year College Faculty  
**Project Number:** 1129271  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Developing Faculty Expertise  

**Goals & Intended Outcomes:** Our project builds and expands on our prior work to increase the number of TUES proposals from two-year colleges (2YC). The overall goal of our work is to broaden awareness of the TUES program as a resource for 2YC and to increase the number of TUES awards to these institutions.

**Methods & Strategies:** Our project combines a grant writing workshop and follow up individualized mentoring developed to assist project participants prepare and submit TUES proposals.

**Evaluation Methods & Results:** Evaluation has consisted of participant and mentor surveys on the quality and impact of the project components as well as statistical data on the participant demographics, numbers of proposals submitted, review results
for submitted proposals, and the number of funded projects. Our results indicate that participants overwhelmingly find the workshop and mentoring to be effective and worthwhile, over half of all participants submit TUES proposals, and that these proposals are generally very well reviewed.

**Dissemination:** We have presented the results of this work at the 43rd IUPAC World Chemistry Congress in July 2011. We will also be presenting at the Biennial Conference on Chemical Education in July 2012.

**Impact:** Over the past three years we have provided faculty professional development to over 100 2YC faculty participants. Each of these participants has utilized this support to help develop a grant proposal to support implementation of STEM teaching and learning initiatives on their home campuses. While only two of our projects have so far received NSF funding, almost all of those originally declined are working to resubmit. Thus, there remains significant potential for broad impact.

**Challenges:** For a number of participants, a significant unexpected challenge was the absence of the needed administrative structures required to simply submit an NSF proposal. As a result, a significant amount of mentor time was spent on addressing this basic problem.

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**55**

**PI:** Richard Fitch

**Institution:** Indiana State University

**Project Title:** Cross-Course Collaboration in the Undergraduate Chemistry Curriculum

**Project Number:** 0942345

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Integration of chemistry curriculum through collaboration between students in foundational courses and advanced courses using enabling technology (GCMS) for each. Our anticipated outcome is greater student engagement and satisfaction, which should lead to increased student performance.

**Methods & Strategies:** Sophomore organic students isolate/synthesize compounds that are passed to inorganic and physical chemistry students who use them experiments requiring specific properties of those compounds and illustrating advanced concepts (regioselectivity, kinetic isotope effects). The latter students report back to the original course the data and interpretation thereof.

**Evaluation Methods & Results:** The project is early yet, but a self-efficacy survey is used for each course at the beginning and end. Minute papers are used as well as in-class observation and focus groups. These are tracked as is overall class performance as evidenced by class grades (all data in aggregate).

**Dissemination:** As this is an early project, this poster is the first dissemination event. Further presentations are planned as well as peer-reviewed publication of results at the conclusion of the project. Web dissemination on the ISU chemistry website is planned also, depending on outcomes.

**Impact:** The principal impact on students is twofold. First collaborative experiences should lead to greater engagement with the course material. Second, mass spectrometry as an enabling technology gives students hands-on experience with state-of-the-art instrumentation, building key skills and enhancing engagement as well. Exposing faculty to course collaboration enhances buy-in (depending on outcomes) and involving them with instrument incorporation also increases the probability that they will use it in further experiments and research.

**Challenges:** The greatest challenge has been with assessment of the project. IRB issues early on and logistical issues with the assessment experts has been ongoing. Finding personnel who are sufficiently disconnected with the project/department but having the necessary expertise in both assessment and chemistry has been challenging. We believe that on-campus personnel with both pedagogical and technical (specifically STEM-oriented) expertise are critical to success.

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**56**

**PI:** Steven Fleming

**Institution:** Temple University

**Project Title:** Bio-Organic Reaction Animations

**Project Number:** 0935049

**Type:** Educational Material Development Full Development (EMD-FD)

**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal is to produce a software package that helps students visualize biomolecules. The intended outcome is that students will be able to manipulate the molecules that they study in bio-organic chemistry. The software will show them the chemistry involved in enzymes, carbohydrates, lipids, and DNA.

**Methods & Strategies:** We are representing chemistry of common enzymes that include each of the classes (ligase, hydrolase, isomerase, o xo reductase, lyase, and transferase). We are providing 3D models of carbohydrates, lipids, and nucleic acids. We have used Spartan, JAVA, J Mol, and Maya to produce the product.

**Evaluation Methods & Results:** We are assessing the effect of the software using student feedback forms, test comparisons between users and non-users, think-alouds, and instructor surveys. We have submitted our results for publication at J. Chem. Ed. We are continuing our evaluation of Bio-Organic
Reaction Animations (BioORA). Each semester we have volunteers helping with gathering data. The goal is to determine whether the software helps students retain information. We know students enjoy using the software. The say that it helps them learn.

**Dissemination:** The software is available online at no cost (www.ctbyu.org/bioora). The PI will continue to advertise the software at national meetings.

**Impact:** The software is still a beta version. We do not have the final analysis on it. There will always be potential for improvement of the software. So the final impact is not possible to answer. We are using the software at 7 schools and there's potential for many more schools to use it.

**Challenges:** Unexpected challenges include the amount of paperwork required to continue the process. Another challenge is getting good data for assessment. It’s nearly impossible to do.

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**57**

**PI:** Kimberley Frederick  
**Institution:** Skidmore College  
**Project Title:** Development and Implementation of an Inquiry-Based, Laboratory-Driven, General Chemistry Sequence  
**Project Number:** 0941951  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:**
- Increase student learning in chemistry
- Improve attitudes about science and learning science
- Improve retention of students in science

**Methods & Strategies:**
- Development of inquiry-based laboratory exercises that use pooled student data
- Using the lab data to introduce the concepts in class in a way that more realistically mirror authentic scientific inquiry
- Implementation of more active pedagogy including POGIL and audience response systems

**Evaluation Methods & Results:** Student learning was assessed using a pre-test and including the same questions on the final. The standardized ACS exam was also administered. Student attitudes were assessed using the chemistry Colorado learning attitudes about science survey (chem-CLASS). Students were also tracked to determine persistence in science

**Dissemination:** A regional pedagogy workshop was held for all 2-year and 4-year institutions and AP high school teachers. The workshop introduced Discovery Chemistry and POGIL methods.

**Impact:** Discovery chemistry has been shown to increase student learning over traditional methods. Discovery chemistry students had a shift to more expert-like attitudes about learning science while traditional method students showed a more novice-like shift. We are also planning to implement Discovery chemistry into the traditional 2-semester general chemistry sequence.

**Challenges:** None other than expected challenges.

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**58**

**PI:** Laura Frost  
**Institution:** Georgia Southern University  
**Project Title:** An Innovative Guided Inquiry Lab Course Integrating Analytical and Biochemistry for Enhanced Student Learning  
**Project Number:** 0736701  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** Students will have increased recall, demonstration, and application of analytical lab skills as they solve problems in both analytical and biochemistry. Students will display higher learning capacity through inquiry based laboratory activities.

**Methods & Strategies:** Enhance student learning in analytical and biochemistry lab courses through requiring the two laboratories in the same semester. A set of inquiry based laboratory exercises that allow students to become more independent learners as the semester progresses were developed.

**Evaluation Methods & Results:** Students in the course were surveyed before, during, and after the course, and their senior year for self-concept and perceptions of learning. Students in the course also completed a lab final which was compared to control cohort.

**Dissemination:** This work has been disseminated at two national ACS meetings, one local SoTL meeting, and via website. The work has also been shared with one other biochemist in the University System of Georgia System.

**Impact:** By the third iteration of the course, faculty are comfortable with the changes and kinks in procedures and the procedures are now standard for the biochemistry I curriculum. Students now perceive the lab to be effective.

**Challenges:** Scale up to a class of 24 undergraduates was challenging. The pitfalls were more than expected initially. We had an undergraduate research student troubleshoot some of the pitfalls which allowed us to correct for deficiencies.
Goals & Intended Outcomes: The goals of the project include increasing non-science majors’ scientific literacy and understanding of chemistry as well as developing chemistry students’ understanding of and skills in using both classic and modern analytical instrumentation and its use in non-science disciplines.

Methods & Strategies: The non-science majors are encouraged to enroll in a laboratory-based introductory chemistry course that uses art as a template for scientific teaching. The chemistry majors take part in an elective course where they perform the technical analysis of works of art using analytical instrumentation.

Evaluation Methods & Results: All students answer pre- and post-surveys which are twofold. The first part is related to their attitude towards chemistry for non-science majors and their knowledge of the use of analytical techniques in art and anthropology for the chemistry majors. The second part of the surveys is chemistry-based and assesses students’ progress in their scientific literacy. Encouraging data have been obtained in fall 2011 and more data will be collected in summer and fall 2012.

Dissemination: A poster was presented at the 2011 Gordon conference on chemical education and more presentations (at SERMACS, ACS, AIC, etc.) are being planned. A website is being created, a contract for a textbook has been signed and the PI is part of the online community of scholars for chemistry and art activities.

Impact: Students have responded positively to the creation of the courses. The chemistry elective course to be taught next is at full capacity. Several chemistry majors are excited to be able to engage in research and in the design of the new courses as part of the grant. Faculty outside of the department (education, art, library, anthropology) inquired about submitting related projects for funding; also art conservators and art historians across the state wish to collaborate. It is expected that, as the project grows, and more dissemination activities are done, the impact will keep increasing.

Challenges: The only challenge has been the scheduling of the first course offered. The introductory chemistry course was scheduled on M, W, F at 9 am with a F afternoon laboratory which was very unattractive for non-science majors who can choose other science courses for their science requirements.

Therefore the enrollment was low. This will not occur again and more students are already enrolled for the fall non-science majors section. Also our new provost asked the science departments to ‘break the cycle of scientific illiteracy’, one of the goals of this project, so we are all heading in the same direction.
**Poster Abstracts**

**Challenges:** Health issues for the PI and one of the Co-PIs has interrupted progress. We are expecting to get back on track in the next week or two.

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**61**

**PI:** David Gingrich  
**Institution:** SUNY Potsdam  
**Project Title:** The Development of Biochemistry Laboratories Centered on Hemoglobin  
**Project Number:** 0737460  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The primary focus is to develop a biochemistry lab sequence organized contextually around hemoglobin and including small research projects. Positive outcomes include enhanced student discovery/problem solving and increasing interest in participating in undergraduate research.

**Methods & Strategies:** The project adapts the research literature as well as existing biochemistry laboratories from the biochemical education literature to develop a two-semester sequence of undergraduate biochemistry laboratories involving hemoglobin.

**Evaluation Methods & Results:** Evaluation methods include attitudinal and pre/post concept assessment. Overall student satisfaction with the full laboratory modules implemented in biochemistry was very significant. 84% of students indicated that they strongly agree or agree the concepts and approaches in the modules would be/were useful in coursework and their future career. More importantly 63% of students expressed a greater interest in participating in research or pursuing careers in research.

**Dissemination:** Preliminary results were presented at the 2011 Student Centered Education in the Molecular and Life Sciences II conference. Locally, students have presented posters describing their class research projects in the local undergraduate research fair.

**Impact:** Students have been introduced to working with proteins in first year chemistry labs and to a more sophisticated use of PCR in the genetics laboratories, in advance of the biochemistry courses. Student assessment is positive and indicates an increased interest in undergraduate research. Increased dialog and cooperation between fellow faculty in both biology and chemistry has occurred.

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**62**

**PI:** Susan Hershberger  
**Institution:** Miami University  
**Project Title:** Collaboration and Guided Inquiry in the Organic Chemistry Laboratory  
**Project Number:** 1044549  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** CGIChem is creating, pilot testing, revising and assessing laboratory guides emphasizing structured collaboration with guided inquiry for greater student academic and affective chemistry achievement.

**Methods & Strategies:** With established materials development protocols, 5 organic instructors and graduate teachers at 3 diverse locations are developing and using student questionnaires to assess new laboratory guides.

**Evaluation Methods & Results:** The primary method of evaluation of the materials uses voluntary student questionnaires on content and affective learning gained immediately following a laboratory investigation. Initial results of 1 investigation show the target group using the structured collaborative materials performing better on all (5) content questions than a control group using similar materials without the structured collaboration.

**Dissemination:** The initial materials and their impact have been shared with organic and chemistry education research faculty at Miami University and are being presented at the 2012 BCCE and the August 2012 ACS national meeting.

**Impact:** This project, following renovation of the laboratory and changes to organic chemistry courses as well as the distribution of students in those courses is part of renewal of chemistry education at Miami. The project’s focus on student centered learning, through structured collaboration and guided inquiry is combining with a departmental focus on student writing in chemistry to improve student achievement and engagement.

**Challenges:** As originally proposed, students work in groups of 4 students, beginning with explicit individual tasks, sharing data and results, and understanding the big picture on organic techniques and reactions. After the laboratory renovations, 2 students share a hood and equipment. As a result, the structured collaboration is being designed for 4 students, 1 or 2 pairs, or 4 pairs of students for greater flexibility.

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**63**

**PI:** Sally Hunnicutt  
**Institution:** Virginia Commonwealth University  
**Project Title:** POGIL-PCL and the Development and Implementation of Guided Inquiry Experiments for Physical Chemistry
**Poster Abstracts**

**Project Number:** 1044624  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The objectives of POGIL-PCL (Process Oriented Guided Inquiry Learning - Phys Chem Lab) are writing, reviewing, and testing experiments with user guides and creating a community of physical chemistry instructors who use the experiments.

**Methods & Strategies:** We will host 3 types of workshops: (1) intensive 2-day writing workshops @ VCU; (2) half-day intro. workshops at meetings like BCCE focused on implementation; & (3) intro 1-day implementation/writing workshops at VCU.

**Evaluation Methods & Results:** First, we will meet our goal for the number & content area of developed experiments (4 to date); the number of participating faculty (12 to date); & the number of students who complete POGIL-PCL experiments (50 to date). This fall we will begin to develop more specific learning assessment tools, such as pre/post-testing, focus groups, and/or strategic observation of students doing experiments.

**Dissemination:** All POGIL-PCL experiments under development are available to participating faculty via Google Docs. Presentations describing this project were given at 2 regional and 1 national ACS meeting; 2 will be given this summer at BCCE and the Philadelphia national meeting.

**Impact:** The impacts at this stage are anecdotal. Students doing POGIL-PCL experiments were observed to be more independent in the lab & were able to initiate & make good scientific decisions in the laboratory. Faculty at the January 2012 workshop were excited to work together to make changes to their phys chem lab courses. Over 75% of participating faculty have already tested at least 1 POGIL-PCL experiment.

**Challenges:** We had no difficulty filling the January 2012 workshop; filling the June 2012 workshop has proven more challenging. Relatively few faculty have experience with POGIL & teach phys chem lab. Presentations at meetings appear to be effective at recruiting new participants.

**Goals & Intended Outcomes:** Our goal is to develop a new 'Organic First' curriculum to replace the traditional general chemistry - organic chemistry sequence. The intended outcome is increased student learning, retention, and/or progression through chemistry and other STEM majors.

**Methods & Strategies:** We have reorganized topics in chemistry into four new courses, using existing textbooks and instructional materials. The sequence starts with organic chemistry and becomes more quantitative as students learn the 'language' of chemistry.

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**65**  
**PI:** Michael Kahlow  
**Institution:** University of Wisconsin - River Falls  
**Project Title:** Redesigning Introductory Chemistry: A Student-Driven Model Curriculum  
**Project Number:** 0736504  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Our goal is to develop a new 'Organic First' curriculum to replace the traditional general chemistry - organic chemistry sequence. The intended outcome is increased student learning, retention, and/or progression through chemistry and other STEM majors.

**Methods & Strategies:** We have reorganized topics in chemistry into four new courses, using existing textbooks and instructional materials. The sequence starts with organic chemistry and becomes more quantitative as students learn the 'language' of chemistry.
Evaluation Methods & Results: We are evaluating students through tracking of demographics (ACT, HS class rank, gender), grades in chemistry courses (ABC/DFW), and progression to the next chemistry course. We are also measuring student attitudes through surveys, and student learning through standardized ACS exams. These assessments are being done on both traditional and Organic First sequences. To date, we have found that student retention and progression in Organic First is no worse than the traditional sequence, and student performance on Gen Chem II topics is better in Organic First.

Dissemination: We have presented our results at several BCCE and ACS meetings. We are in the process of writing a manuscript describing the curricular changes. We are also in preliminary discussions with other institutions with similar programs for possible joint dissemination/evaluation efforts.

Impact: The effect on the students is still not clear. Some students have benefitted, but the failure rate (DFW) in the new sequence is comparable to the traditional curriculum. The project has energized our faculty, department, and institution. This project is responsible for our department hiring a faculty member in Chemical Education. Our institution is considering submission of an NSF-STEP proposal to bring similar reforms and approaches to all of the campus STEM programs.

Challenges: One challenge has been the views of faculty in other departments. We have had inconsistent advising into this course sequence, and as a result have had differing cohorts in the courses, making assessment efforts difficult. Another challenge was that in our original course sequence, the third course was an inorganic chemistry course. After two years, assessment showed that students were not prepared for this, so the course was changed to reflect General Chemistry II knowledge and content. This change was successful in that students now outperform our General Chemistry II students in ACS exams.

Methods & Strategies: Educational process is most effective if the students are stimulated to want to learn the material. Following a crime scenario at which the participants collect evidence, they investigate the evidence collected and the evidence submitted to the crime lab as the police investigate the crime. The lectures provide the theoretical basis for the experimental procedures.

Evaluation Methods & Results: The participants are asked to complete a number of assessments; first to determine their knowledge before the workshop and then to assess their knowledge after the workshop. They are asked to complete an evaluation after they have had a chance to implement the material learned during the workshop into their courses. The results of these questionnaires are used to further develop the workshop and to refine material to improve the content and the presentation.

Dissemination: The activities of the workshop and the scholarly activities of the alumni are posted on the Forensic Science Scholars website. Additional activities are reported in the professional education literature both by the PI and workshop alumni.

Impact: More than 300 participants have taken the forensic science workshop. Many have returned to their home institution and developed experiments, lecture modules, courses, even programs in forensic science as a result of what they experienced in the workshop. The impact has extended to tens of thousands of students.

Challenges: Surprisingly the academic and scientific aspects of conducting the workshops has progressed rather smoothly. Major challenges have involved the administrative aspect of conducting the workshop with trying to coordinate the special needs of the participants. This, however, was expected and is dealt with on a case by case basis.

66
PI: Lawrence Kaplan
Institution: Williams College
Project Title: Collaborative Research: Chemistry Coalitions, Workshops & Community of Scholars
Project Number: 1022954
Type: National Dissemination (ND)
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: To conduct a week-long forensic science workshop for college and university faculty. The workshop has a major experimental component that gives the participants experience with all of the major equipment and techniques used in a crime laboratory. To develop a community of forensic science scholars so that the teaching/learning process will continue for all involved.

67
PI: Tracy Knowles
Institution: Bluegrass Community and Technical College
Project Title: Team Science: Using Team-based Learning Strategies to Increase Student Success in Science Courses
Project Number: 0942089
Type: Phase 1/Type 1 - Exploratory
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: The goals of the project are to positively impact the instructional culture and student learning outcomes in selected chemistry and biology courses using team-based learning concepts (TBL).

Methods & Strategies: A 40 hour workshop provided training by leading TBL experts. A peer mentoring program has been
established for use during curricula redesign and implementation phases.

**Evaluation Methods & Results:** TBL evaluation plans include measuring changes in student achievement and engagement, efficacy of faculty training in improving knowledge of TBL techniques, and student perceptions of the efficacy of TBL techniques.

**Dissemination:** Faculty have attended multiple local, regional, and national conferences to both present data as well as conduct workshops in the basics of the TBL method.

**Impact:** We have trained eleven faculty members in the basics of course redesign and team-based learning (TBL). Six majors Chemistry and Biology courses have been redesigned to use the TBL format. Over fifty sections of these courses have been taught using full or partial TBL format. Total Unsatisfactory Achievement (TUA receiving a D, E, or W grade) in many of these courses has decreased and student performance on embedded questions have improved as compared to traditional lecture sections.

**Challenges:** Unexpected challenges include difficulty in designing application projects and student resistance to working in teams with minimal lecture.

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**68**

**PI:** Juliette Lantz  
**Institution:** Drew University  
**Project Title:** A New Approach to Analytical Chemistry: The Development of Process-Oriented Guided Inquiry Learning Materials  
**Project Number:** 0717492  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** 1) To develop and assess student-centered guided inquiry materials that enhance student learning and process skills in analytical chemistry. (2) To develop a community of scholars to enhance analytical chemistry instruction in the classroom including the development of strategies to help faculty implementers assess process skills.

**Methods & Strategies:** We are using a consortium model to write, test, and assess these POGIL analytical chemistry materials. The development phase included extensive peer and student review followed by classroom testing by additional faculty. A mixed methods approach has been used to assess the impact of the activities on student learning and attitudes.

**Evaluation Methods & Results:** Evaluation of the development of activities has been done through a review process. Quantitative methods of assessing student learning and attitudes include the ACS Quantitative Analysis Exam, SALG, and ChemX. Qualitative methods of assessing students include open-ended exam questions, student reviews of activities, and think-aloud problem solving interviews. Data has been collected from several institutions representing a broad variety of types and sizes. Data analysis has not yet been completed.

Oversight and external evaluation have been provided by an advisory board which included representatives from STEM education research, academia, and industry.

**Dissemination:** We have facilitated workshops at BCCE 2008, 2010, and 2012 on implementing our materials. To date, 28 presentations on this project have been made at national/regional scientific meetings, and the project website appears on the ASDLIB.org website. Publication of curricular materials through the POGIL project is being pursued.

**Impact:** 17 faculty and one graduate student at 15 institutions directly associated with the project have been incorporating our materials, implementation strategies, and assessment procedures in their classrooms. The project has directly impacted their professional development and the learning environments of over 400 students. Numerous faculty have launched other grant projects or institutional projects that branch off the original project. Faculty outside the project have attended workshops and/or requested materials. Our consortium has consulted on several other guided-inquiry material-generating projects in other disciplines.

**Challenges:** Making sure that ownership of the project belonged to all consortium members (establishing goals, remuneration, meeting times) was accomplished through dedicated discussions early on in the project. Tracking the developmental stage of numerous activities with multiple authors was handled through an extensive Blackboard site. Developing and training in implementation strategies happened at consortium meetings and at other meeting/workshop venues. Managing a grant project that involved extensive travel was facilitated by a staff member from the POGIL national office. Extensive data analysis required the addition of a post doc and a one year extension.

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**69**

**PI:** Matthew Miller  
**Institution:** South Dakota State University  
**Project Title:** Fostering an Induction into Authentic Research in the Freshman/Sophomore Sequence  
**Project Number:** 1044419  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** 1. Create and implement a model of laboratory instruction based on departmental research initiatives using proven pedagogical strategies. 2. Collect
evaluation data to assess efficacy of the model. 3. Determine portability of the model to other institutions.

Methods & Strategies: 1. Mentorship between first and second cohorts 2. Enhanced interplay during experiments between students in CHEM 229 and CHEM 115 3. Dialogic interaction between the cohorts in terms of laboratory activities, experimental outcomes, and what the derived data means collectively.

Evaluation Methods & Results: 1. Survey of undergraduates participating in the research to determine interest in research 2. Use ACS diagnostic exam to test the level of conceptual knowledge to assess content knowledge 3. Problem solving interviews to assess critical thinking 4. Observation of student work in the laboratory to identify interactions between students 5. Surveys completed on a monthly basis and interviews will be conducted as a result of survey feedback to describe student-student interactions 6. CAT exam from Tennessee Tech to assess critical thinking

Dissemination: 1. Make details of model available in the form of peer-reviewed publications 2. Conduct workshops at campuses to promote and disseminate evaluation outcomes (BCCE 2012) 3. Present the model at national science and education conferences 4. Assist other institutions in adopting this model as necessary.

Impact:
- Develop a community of practice among chemistry and biochemistry majors from the start of their training
- Synthesis of chemical theory to laboratory application
- Hands-on training with sophisticated instrumentation
- Increased problem solving and critical thinking skills
- Higher motivation to learn chemistry and participate in research
- Improved oral and written communication
- Introduction to authentic research practices within the department.

Challenges: Currently our unexpected challenge was the timing for obtaining the grant. We were officially informed of the grant in August 2011. Our timeline for implementation was to have the summer months prior to the first semester to plan and prepare materials, and install instrumentation. We have utilized the first year as a pilot to try various components of the proposal; 1.) implemented several interactive experiments and 2.) involved faculty in project brainstorming methods.

Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goal of this project is to develop a series of integrated laboratory activities that target cognitive skills specific to inquiry-based learning in the laboratory and target ability to transform concepts between macroscopic, particulate and symbolic representations.

Methods & Strategies: Development of the lab activities is guided by a Learning Continuum that reflects a progression of cognitive and conceptual development. Each activity will be assessed in a pilot study, reviewed by external experts, revised and re-evaluated in a series of replication studies.

Evaluation Methods & Results: We plan to evaluate the laboratory materials in terms of instructor use, student use, and impact on student learning. Faculty reviewers will provide feedback on whether the targeted cognitive and conceptual objectives are present. Surveys and interviews with students will be used to assess their perception of the laboratory activities. The cognitive and conceptual objectives will be assessed using established instruments where available, with new measures developed as needed. In collaboration with the PI's, an external evaluator oversees the evaluation process.

Dissemination: To date we gave one invited presentation at ACS WRM and two posters with undergraduates at a NKU conference. At BCCE, three posters with undergraduates will be presented plus a symposium on lab learning organized by the PI's. A project website is also used for dissemination.

Impact: Two lab activities were piloted in the spring 2012 term, involving over 100 students on two campuses. We anticipate that an average of 300 students per year will be directly impacted by the new curriculum and will help to develop skills that advance their academic and professional pursuits. As the project matures, we anticipate that colleagues at other institutions will adopt/adapt the materials to provide an enriched learning experience in the laboratory.

Challenges: The award notification during the summer left little time to develop activities for pilot implementation in the fall. We revised our project timeline to focus on development the first semester. We've also made use of Internet-based resources such as Skype, Google Docs and Dropbox to facilitate coordination between the two sites. We also had to adapt our project Website structure to fit available resources at the lead institution.

70
PI: Kereen Monteyne
Institution: Northern Kentucky University
Project Title: Collaborative Research: An Integrated Cognitive and Conceptual Curriculum for a General Chemistry Inquiry Laboratory
Project Number: 0104403

71
PI: Shaun Murphree
Institution: Allegheny College
Project Title: Introduction of a Guided-inquiry Curriculum in Organic Chemistry by Means of Microwave-assisted Synthesis
Project Number: 0837640
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To develop a more engaging and authentic sophomore organic laboratory experience by developing a curriculum in which students can not only carry out experiments, but also engage in experimental design, analysis, troubleshooting, and reaction optimization during the laboratory period.

Methods & Strategies: Rapid reactions are developed using microwave-assisted organic synthesis (MAOS) and systems are chosen which can be followed by short (<5 min) HPLC procedures. Students explore this chemistry with the support of new laboratory materials (e.g., case studies and technique primers).

Evaluation Methods & Results: A survey instrument was constructed using items from the Attitudes Toward Science Inventory, the Views on Science and Education (VOSE) Questionnaire, the Views of Nature of Science Questionnaire, and the Science Laboratory Environment Inventory. Encouragingly, the results show that the new curriculum yields improvement in affective parameters (enjoyment), a stronger perceived link with lecture, and an enhanced social aspect of the laboratory environment, which should be conducive to more effective collaboration.

Dissemination: Results have been presented at regional and national ACS meetings, the Mid-Atlantic Association of Liberal Arts Chemistry Teachers (MAALACT) conference, and the Lilly Conference. A talk will be presented at the BCCE this year, and a manuscript for J. Chem. Educ. is in preparation.

Impact: Students are engaging in the chemical concepts of the laboratory at a noticeably higher level. Up to now, the new curriculum has only been piloted in two of the six organic chemistry sections. However, based upon the success of the model, we are planning to fully implement a revised lab curriculum in the upcoming academic year. The team-based approach is also being introduced to the introductory chemistry laboratory.

Challenges: There were two major surprises. First, since the organic lecture course incorporates peer-led team learning (PLTL) workshops, we assumed that this mindset would flow seamlessly into the lab. This was not the case. Consequently, group work had to be carefully scaffolded in the materials. Second, the new curriculum develops many new skill sets. In the first year of the project, some students found this overwhelming. In subsequent years, new skills were introduced throughout the semester in cascading fashion, with much better results.

72
PI: Pushpalatha Murthy
Institution: Michigan Technological University
Project Title: Enhancing Active Learning: An Inquiry-based Laboratory in Biomolecular Chemistry
Project Number: 0837220
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The goal is to develop a semester-long, inquiry-based laboratory course in biomolecular chemistry that familiarizes students with protein and nucleic acid techniques through open-ended experiments and active involvement in the research process. The emphasis of the course will be on acquiring critical thinking skills such as data evaluation, data interpretation and data defense in an oral session in from of the class.

Methods & Strategies: We have developed a series of eight open-ended experiments that will guide students to become progressively more independent, and culminate in a student-developed original research project. The unique feature is an oral data presentation and data defense session for each experiment before the written report is submitted.

Evaluation Methods & Results: Dr. Hungwe, from the Department of Cognitive and Learning Science, carried out the formative assessment. The evaluation process was based on multiple sources of data. The sources of data used were: (1) student self-assessment of their learning and the pedagogical environment; (2) instructor goals for the course; (3) student performance on course assessments; and (4) classroom observations by the evaluator.

Formative evaluations from 2010 and 2011 was used to inform changes every year.

Dissemination: We have presented the results of our project at the following meetings:
- American Chemical Society national meeting, Boston, August 2010
- NSF-CCLI Conference, Washington DC, January 2011
- American Chemical Society, national meeting, Denver 2012.

Impact: We have enhanced science education at the college level by incorporating new laboratory teaching methods and training the next generation of students with up-to-date equipment. The laboratory exercises were open-ended and required active participation and emphasized question formulation, data gathering, critical analysis, and communication (oral and written) skills. The oral data presentation and data defense session before submitting the written report has had a significant impact on the learning process of students.
Challenges: A major challenge was the resistance from students to the new laboratory format which requires reflective learning. They are used to the traditional format and the new format required them to go out of their comfort zone. Students were not comfortable with the ambiguity and uncertainties generated by research data; they wanted a clear answer to fall out of the first set of data they generated.

The GTAs were also challenged because each student/student group was conducting a different set of experiments and the outcomes to all experiments was not known.

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PI: Leah O’Brien
Institution: Southern Illinois University Edwardsville
Project Title: Isothermal Titration Calorimetry in Upper-level Physical Chemistry and Biochemistry Laboratory Courses
Project Number: 0941517
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We have four project goals: (1) bring the latest developments in ultrasensitive ITC into the undergraduate experience; (2) develop hands-on laboratory experiments for upper-level students in our programs; (3) develop faculty expertise, implement education innovations, assess learning and evaluate innovations; and (4) promote widespread implementation of education innovations through dissemination and conference participation.

Methods & Strategies: New experiments were developed based on the research literature, handouts were tested and revised several times. To date two experiments have been fully developed: Binding of EDTA with Ca2+ and Mg2+ and ITC and Macromolecular Modeling of the Interactions of Lysozyme and its Inhibitors. These experiments provide instructions, discuss good laboratory techniques, and describe proper care of the ITC equipment.

Evaluation Methods & Results: An external evaluator has reviewed student laboratory reports from Physical Chemistry Laboratory to assess the level of critical thinking displayed in these reports. Analysis shows that students were more successful in thinking linearly about direct causes and consequences, but less successful in thinking broadly (suppose conditions were altered, what then?).

Dissemination: Two manuscripts are in final preparation for submission to the Journal of Chemical Education.

Impact: This project has attracted interest from faculty in our School of Pharmacy, and led to several new collaborations and student projects.

Challenges: We did not realize how difficult it is for students to accurately prepare dilute solutions. We do not want to give cookbook instructions but now we point them toward making a 100x solution and then dilute to the concentration to be used in the experiment.

74

PI: Jerry Smith
Institution: Georgia State University
Project Title: Collaborative Research: Chemistry Coalitions, Workshops, and Communities of Scholars
Project Number: 1022895
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: The target audience for cCWCS activities is faculty and staff from community colleges, traditional four-year institutions, and comprehensive universities. The goal of the Program is to enhance instruction and learning in the chemical sciences, broadly defined primarily at the undergraduate level.

Methods & Strategies: The Program conducts intensive workshops in both pedagogical and topical areas of the chemical sciences. We also sponsor symposia at national meetings featuring the use of workshop materials by former participants in their instruction. Three Mini-workshops will be run at the BCCE in 2013.

Evaluation Methods & Results: From its inception, the Program has served 1829 participants from 1140 institutions located in all 50 states plus the District of Columbia, Guam, and Puerto Rico; some 113 workshops have been run at 34 diverse locations. The learning of 1,000,000 students has been impacted by Program. End-of-workshop evaluations are conducted to gauge the viability of individual workshops and to score the increase in knowledge gained by participants in topic-specific areas. Longer term evaluations are conducted by participant telephone interviews and by evaluations at the individual student level.

Dissemination: The model based on intensive workshops supplemented by symposia at the ACS and BCCE meetings plus mini-workshops at the BCCE is mature and will be continued. Diversification of effort via development of learning centers based on the leadership of former participants is in progress.

Impact: A number of workshops (e.g. nucleic acids, NMR, medicinal chemistry, etc.) involves efforts from multiple faculty members from one or more departments or institutions. The chemistry department at Georgia State University is undergoing a massive expansion; such exposure is helpful. Other mobile workshops are often held at diverse locations and may require both local and imported instructors or organizers. Both undergraduate and graduate students are utilized as assistants.
in the Program especially in the laboratory or hands-on activities.

**Challenges:** The development of Community of Scholars in selected areas and the supporting websites has proven to be a challenge. The Program Directorate is assembling leadership groups for each of the areas under development: Forensic Science, Chemistry in Art, and more recently Nanotechnology. The website issues were resolved by use of institutional expertise, sheer perseverance, and by use of DRUPAL.

**75**

**PI:** Glena Temple  
**Institution:** Viterbo University  
**Project Title:** Development of a Two-semester Inquiry-based Capstone Laboratory Experience for Biochemistry Majors at Viterbo University  
**Project Number:** 0837347  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** The overall goal was to strengthen the student learning in the biochemistry major at Viterbo University through: 1) alignment and assessment of laboratory skills based on ASBMB standards, 2) integration of inquiry based methods into laboratory courses, 3) faculty development related to key skills.

**Methods & Strategies:** The outcomes were achieved through: 1) acquisition of new laboratory equipment, 2) training of faculty in state-of-the-art techniques, 2) increased emphasis on assessment and inquiry based methods, 3) alignment of laboratory skills throughout the biochemistry curriculum.

**Evaluation Methods & Results:** The grant used multiple methods to assess the impact. These methods include: 1) student surveys, 2) focus groups, 3) measures of student learning outcomes through standardized ACS exams, lab reports, exams, and other learning outcome measures. Students reported high satisfaction with the revised curriculum. Over 90% of students indicated they were satisfied with the lab experience. We measured over a 30% increase in student scores on rubrics assessing student learning on key laboratory concepts. In addition, lab reports demonstrate improved student learning and confidence.

**Dissemination:** The results of the renovations to one of the key courses in the curriculum was presented as a poster at the Experimental Biology meeting in 2011. Currently, the grant team is preparing manuscripts for publication on two different aspects of the project.

**Impact:** The program has had significant impact on the strength of the biochemistry major at Viterbo University. Prior to the grant, students lacked exposure to several key laboratory skills, and did not have the opportunity to employ inquiry based methods in their capstone courses to think critically about laboratory experiments in biochemistry. The grant has had strong positive impacts on student satisfaction, student learning outcome measures, performance on ACS standardized test questions (related to lab), and alignment with ASBMB recommended laboratory skills.

**Challenges:** We found we needed to modify some of the proposed activities, due to high variability in student results in the lab. This has led to stronger laboratory activities, but it was not expected at the beginning of the project. We are preparing these new laboratory methods for publication currently to demonstrate the impact on student learning.

**76**

**PI:** Marcy Towns  
**Institution:** Purdue University  
**Project Title:** Visualizing the Chemistry of Climate Change  
**Project Number:** 1022992  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** This project is developing a series of online digital learning objects and examining the efficacy of these tools by measuring changes in understanding by undergraduate students about both climate change and core chemistry concepts taught through climate change science. The project also is producing a tested inventory of climate change concepts for use in further research.

**Methods & Strategies:** Development of the Digital Learning Objects is taking place with a collaborative team at Kings Centre for Visualization in Science. They have created a site www.explainingclimatechange.ca which will be used to leverage the development of DLOs in this project. The DLOs are being implemented at a variety of institutions including Purdue University where formative and summative assessments are taking place. We additionally have interviewed 24 general chemistry students about their understanding of the chemistry of climate science.

**Evaluation Methods & Results:** We have formative and summative assessment data demonstrating student understanding of concepts associated with the modules. A usability study is also underway with our evaluator Dr. Tom Holme at Iowa State University. Results of this project would be available for dissemination in January 2013. We are analyzing the 24 interviews collected in fall 2011 about the student understanding of the chemistry of climate science and will have completed that portion of the project by 2013. Initial findings from that part of the project have been disseminated at the ACS meeting in March 2012 and the National Science Teachers Association meeting in March 2012.
Dissemination: Three talks were delivered about the project at the March 2012 ACS meeting and one talk was delivered at the National Science Teachers Association meeting in March 2012. Two workshops are scheduled—one at the International Conference on Chemical Education in Rome in July 2012 and one at the Biennial Conference on Chemical Education at Penn State in July 2012. The analysis of the 24 interviews will result in a publication.

Impact: The project visibility has been raised quite a bit by our dissemination efforts. We had a large number of high school teachers interested in using these materials that talked with me at the National Science Teachers Association meeting after my talk. (There were 50 people attending the talk.) Peter Mahaffy was recognized with the ACS-CEI award in March 2012 due to his work in this area including this project. At Purdue more faculty know about this project and are using it in their courses.

Challenges: The travel budget between the US and Canada is not large enough for the project.

77
Pi: Harry Ungar
Institution: Cabrillo College
Project Title: Community College Chemistry Faculty into Bridging College Chemistry Faculty into National Educational Community
Project Number: 0737166
Type: Phase 1/Type 1 - Exploratory
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: 1) Improve chemical education in community colleges through faculty development; 2) promote undergraduate research and new teaching methods; 3) connect more community college faculty to the national community of chemical educators; and 4) improve student transfer.

Methods & Strategies: We create symposia of particular interest to community college faculty at meetings of the American Chemical Society (ACS) and provide support for them to attend. We are publishing a Guidebook for faculty to improve student transfer from two to four year institutions.

Evaluation Methods & Results: Joe Mattoon, an external evaluator, analyzed audience responses for every symposium and workshop offered, and was present during two of them. Evaluation instruments were designed for the three different types of sessions: individual presentation, panel discussion, and a symposium that included multiple presenters. Results from all these questionnaires were extremely positive.

Dissemination: Almost all ChemEd Bridges work involves dissemination of information to chemistry faculty. We recently completed a workshop on student transfer from two to four year institutions and are preparing a publication for national distribution that includes recommendations to improve faculty involvement in this important process.

Impact: Over the course of the grant, over 200 faculty have attended our symposia and workshops, with over 80 of them at the recent San Francisco ACS National Meeting. About 50 faculty have received travel awards. We hope that the publication mentioned above will have a significant impact on student transfer.

Challenges: During the first 18 months of the project, the number of applications for travel support was surprising low, but at our most recent meeting there were more than 20 applications. As CEB grew and become better known, the number of applicants and the interest of 2YC faculty has increased substantially.

78
Pi: Pratibha Varma-Nelson
Institution: Indiana University Purdue University Indianapolis
Project Title: Cyber PLTL (cPLTL): Development, Implementation, and Evaluation
Project Number: 0941978
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Create Cyber PLTL (cPLTL), an online collaborative environment for conducting PLTL Workshops. Study the effectiveness of a cPLTL environment in duplicating the proven benefits of the traditional (face-to-face) PLTL method. Examine the effectiveness of the existing PLTL materials in cPLTL Workshops. Modify the existing training course for the peer leaders to be effective facilitators in the cPLTL model. Develop brief technology training for students learning chemistry in cPLTL workshops. Articulate the critical components vital to successful implementation of a cPLTL program.

Methods & Strategies: A team of instructional design and instructional technologists are working together to design cPLTL and evaluate it.

Evaluation Methods & Results: Qualitative as well as quantitative.

Dissemination: We have given numerous workshops and presentations at local and regional ACS meetings, local and regional EDUCAUSE meetings. I have given workshops at various colleges and universities as well.

On June 25-27, 2012, we held a national adoption workshop on our campus in Indianapolis for about 25 invited attendees. Attendees consist of teams of professors and instructional technology folks. We have more applications than the number we can accommodate.
Goals

Focus: Project

Type: contextual ASDL under implementation

PI: faculty committed assessment schools

Challenges: student and technology Difficulties we have encountered is having other institutions try it on their campus. The variability is in the technology and training available to the students. We have instructional technologists working with the faculty in other schools who are trying to adopt cPLTL in biology.

Dissemination: We are putting materials on the Analytical Sciences Digital Library, all of which are subjected to an anonymous peer review process by individuals not part of our curricular effort. We have given numerous talks on the project at venues such as Pittcon and American Chemical Society meetings. This includes symposia that we have been invited to organize at both meetings where various project participants have given the majority of talks at the symposium. Outcomes of our CCLI Phase I award have been published in two articles in the Journal of Analytical and Bioanalytical Chemistry.

Impact: Materials developed to date through our project have been used in almost 20 undergraduate chemistry departments in analytical chemistry courses ranging from 5-50 students. Overall we expect the project to impact well over 1,000 undergraduate students and 20 faculty members a year. These individuals are at research universities, HBCUs and public and private predominantly undergraduate institutions. Faculty members involved in the project have become better at incorporating active learning exercises into the classroom and laboratory.

Challenges: It is challenging coordinating such a large development team and keeping everyone on task, but that was not necessarily unexpected. We meet twice a year in face-to-face meetings, which has facilitated our ability to make progress on the development and implementation of materials.

Methods & Strategies: We have a team of collaborators from over 20 institutions who are developing materials. This includes faculty members from R1s, HBCUs, and private and public predominantly undergraduate institutions. Materials include text resources, in-class problem sets, laboratory projects, contextual problem-based modules and instructor’s manuals for all the materials being developed. Members of the team are committed to deploying any materials developed when the topic fits into something they teach in their own courses. Faculty development on the use of active learning strategies is a secondary focus of our efforts.

Evaluation Methods & Results: We are using a variety of evaluation methods. One involves student performance on exams in courses, with a comparison of pre- and post-implementation of active learning exercises. We are designing pre- and post-course questions or tests that will monitor student progress accomplished through the use of the active learning materials. We are collecting survey information from student and faculty users of new material. Outcomes of the assessment will be used to revise the materials. There are no results for the new materials under development but assessment data from a CCLI Type 1 award in which we piloted some materials showed better student achievement on exams and general satisfaction among students and faculty for the materials.

79

PI: Thomas Wenzel

Institution: Bates College

Project Title: Development of E-Learning Modules for Analytical Chemistry

Project Number: 1118600

Type: Phase 2/Type 2 - Expansion

Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goal is to put an entire active-learning based undergraduate analytical chemistry curriculum on-line through the Analytical Sciences Digital Library (ASDL). ASDL was started through NSF grants and is now funded through the analytical division of the American Chemical Society. Materials for use in both the classroom and laboratory are under development.

Methods & Strategies: We have a team of collaborators from over 20 institutions who are developing materials. This includes faculty members from R1s, HBCUs, and private and public predominantly undergraduate institutions. Materials include text resources, in-class problem sets, laboratory projects, contextual problem-based modules and instructor’s manuals for all the materials being developed. Members of the team are committed to deploying any materials developed when the topic fits into something they teach in their own courses. Faculty development on the use of active learning strategies is a secondary focus of our efforts.

Evaluation Methods & Results: We are using a variety of evaluation methods. One involves student performance on exams in courses, with a comparison of pre- and post-implementation of active learning exercises. We are designing pre- and post-course questions or tests that will monitor student progress accomplished through the use of the active learning materials. We are collecting survey information from student and faculty users of new material. Outcomes of the assessment will be used to revise the materials. There are no results for the new materials under development but assessment data from a CCLI Type 1 award in which we piloted some materials showed better student achievement on exams and general satisfaction among students and faculty for the materials.

80

PI: Steven Wood

Institution: Brigham Young University

Project Title: ChemCompanion; A Digital Text for the First-Year college Chemistry Course

Project Number: 0837803

Type: Phase 1/Type 1 - Exploratory

Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We have produced a novel web-based first-year chemistry text that presents visual media simultaneously with the delivery of a spoken text. We have prepared these materials with a strong conceptual focus and have incorporated this focus into the presented sample problem solutions.

Methods & Strategies: A variety of visual elements are presented in conjunction with the text. These include video clips, still photos, illustrations, written words and information, and animations. We have also developed an animated format for presenting sample problem solutions that incorporates core chemical concepts and a just-in-time math review of the math concepts required to solve the problem.

Evaluation Methods & Results: We have utilized student surveys and focus groups. This evaluation has been done in conjunction with our campus Center for Teaching and Learning. The student reaction to the materials is overall very positive. We have also had external faculty reviews of the materials. Both
student comments and faculty reviews pointed out the lack of worked out sample problems in the materials. It was clear that these were viewed as an essential component.

**Dissemination:** Both posters and presentations on the project have been presented at chemical education conferences and at a Gordon Conference. The materials have been used for the past few years as part of the general chemistry course taught by the PI.

**Impact:** About 1000 students in the general chemistry courses taught by the PI have had access to the materials produced thus far. The response to the materials has been very positive. The faculty response to a formal presentation of the project materials was very favorable, especially to the animated sample problem solutions. This spring the project materials will be used in a one-semester general chemistry course as the text. We anticipate positive reaction based upon previous experience.

**Challenges:** We initially concentrated on the writing and producing the course content, but our evaluations soon revealed that the example sample problems in a text are viewed as essential by both students and faculty alike. We had to devise a way to present the solution to these problems such that we could take full advantage of this text’s unique visual environment.

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**81**

**PI:** David Woon  
**Institution:** University of Illinois at Urbana-Champaign  
**Project Title:** Discovering the Nanoworld: A New Module for Teaching About Molecules and Bonding in General Chemistry  
**Project Number:** 0942090  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We are creating a new module on atoms, molecules, and bonding that will be disseminated online. It will include a full set of instructional materials: a web book, computer labs, sample questions, and additional teacher resources. The effectiveness of the material will be tested with a new assessment instrument.

**Methods & Strategies:** We are incorporating active learning through questions asked, encouraging the students to anticipate what is coming next. The materials will be very visual and will be supported with real-world examples as much as possible.

**Evaluation Methods & Results:** Assessment will be performed with a new instrument that is currently being developed. Data has been collected on a set possibly questions to determine which will exhibit sufficient discrimination when testing the module. We will also perform one-on-one evaluations with volunteer students.

**Dissemination:** Dissemination will be through a website that is under development. This will be supported with talks presented at relevant meetings and publications about the module and about the assessment activities.

**Impact:** We are revising a core segment of the general chemistry curriculum, which will impact both students and the faculty who teach the material.

**Challenges:** N/A

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**82**

**PI:** David Yaron  
**Institution:** Carnegie Mellon University  
**Project Title:** Online Chemistry: Problems, Concepts and Contexts  
**Project Number:** 1123355  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** This project is creating a set of online instructional materials for topics in introductory chemistry that are difficult to teach and learn. By better coupling problem solving to chemical concepts, the materials help maximize the benefit of the extensive time students now spend solving problems.

**Methods & Strategies:** The materials implement new approaches to teaching chemical equilibrium and thermodynamics that are based on years of research on student learning of these topics. In particular, the new approach to chemical equilibrium has been shown to more than double student performance on difficult problems.

**Evaluation Methods & Results:** The materials are implemented in an online course delivery system that collects a detailed log on student interactions with the materials. Detailed information is thereby gathered on how students learn. Since the materials are developed in a manner that allows for easy modifications, even for highly interactive components, both the original authors and the community as a whole can use the information gleaned on how students learn to iteratively improve the materials. The course delivery system is designed to allow for controlled studies on the impact of such modifications.

**Dissemination:** Dissemination is done through the internet, conferences, and publications. The materials will be part of the ChemCollective digital library, which is accessed over 300,000 times a year. We regularly present at educational conferences, have a booth in the exhibition hall and run workshops. Results are published in both chemical education and learning science journals.

**Impact:** The educational materials are based on years of ongoing research regarding the way students learn chemistry
and ways to improve learning. In addition to being directly usable by students, the materials helps instructors learn the new instructional approaches. In addition to this impact on students and instructors, the materials are being implemented in a manner that allows collection of detailed data on student interactions and the creation of conditions for controlled studies, to support work by learning researchers.

**Challenges:** The project is in its early stages and we have not yet run into unanticipated challenges.

**COMPUTER SCIENCE**

**83**

**PI:** Nicoletta Adamo-Villani  
**Institution:** Purdue University  
**Project Title:** Building a Serious Game to Teach Secure Coding in Introductory Programming  
**Project Number:** 1022557  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Design, develop and assess the effectiveness of a serious game and accompanying lab modules to teach information assurance concepts to undergraduate students in CS.

**Methods & Strategies:** We use a serious game approach to provide a motivating context for introductory computer science topics.

We use the serious game and accompanying curricular materials at several (at least 5) institutions.

**Evaluation Methods & Results:** A formative evaluation will be conducted to rate the usability of the game, quality of the graphics, gameplay, user engagement and overall usefulness of the tool. A summative evaluation with CS undergraduate students will be conducted to determine the learning outcomes from using the game.

**Dissemination:** Primary dissemination will be done through three channels: to the IA education community, through the ATE centers, and to the CS education community.

**Impact:** We are working with two of the IA NSF Advanced Technological Education (ATE) Centers, the Cybersecurity Education Consortium (CSEC) centered at the University of Tulsa, and the CyberWatch Center, centered at Prince George's Community College. These centers will both try out our materials, as well as serving as dissemination vehicles. We will also make our materials freely and publicly available on the web, and communicate with the 30+ funded SFS programs.

**Challenges:** N/A

**84**

**PI:** Stephanie August  
**Institution:** Loyola Marymount University  
**Project Title:** CCLI: Enhancing Expertise, Sociability and Literacy Through Teaching Artificial Intelligence as a Lab Science  
**Project Number:** 0942454  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** TAILS explores whether structured labs with exercises that are completed in teams before students leave the classroom can build a sense of accomplishment, confidence, community, and collaboration among students, characteristics shown to be critical to retain women and non-traditional computer science students in the field. The approach is expected to encourage cooperation and teamwork among students, attract those drawn to collaborative models of working, and increase participation in the field by exposing undergraduate students to research.

**Methods & Strategies:** TAILS is creating learning materials to teach artificial intelligence (AI) concepts using an experiment-based approach modeled after the laboratory sciences. The activities provide experience with concepts from multiple perspectives and multiple modes of representation. Best practices in software engineering will be reinforced in students through careful design and documentation of the modules.

**Evaluation Methods & Results:** Formative evaluation will take place in the classroom and during summer workshops. Summative evaluation will consist of three components. First, workshop attendees will be assessed at the end of the workshop. Second, students in undergraduate AI courses at the PI’s home institution will be assessed at module boundaries, at end of semester, and after graduation. Third, faculty members teaching AI courses at LMU and other institutions using TAILS will be asked to judge its effectiveness in developing community and collaborative relationships among students and improving the students’ ability to communicate concepts from multiple perspectives and at multiple levels of abstraction.

**Dissemination:** Published paper and poster presentation, ASEE 2012 NSF Grantees Session. Paper on searching the TAILS database submitted to the 2012 International Conference on Web Information Systems and Mining. Future activities: summer workshops with faculty and students from other universities and industry representatives; stakeholder meetings; conference and journal publications; website.

**Impact:** By using AI modules in the introduction to computer science for non-majors course, TAILS reaches out to and potentially recruits from populations not otherwise exposed to such advanced material. In a senior-level AI course, the modules
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provide an opportunity to expose students to a wider variety of applications than would be possible if they had to implement each algorithm from scratch. By exposing students to experimenting with and extending code and viewing it in the context of a particular application, the time required to prepare undergraduate students to engage in research is shortened. The well-documented modules can be used independently by other faculty to demonstrate algorithms, as exemplars of program design, for programming exercises, and by managers and engineers to gain a basic understanding the characteristics and behavior of commonly occurring algorithms.

Challenges: TAILS faced three challenges. First, the virtual environment Second Life was selected for implementing and visualizing conceptual a clustering algorithm. However, this platform is both unstable and unable to meet the computational demands of the algorithm. Clustering will have to be implemented using a more conventional environment and programming language. Second developing interactive, multimedia learning modules that provide engaging visualizations of real-world applications and work on multiple platforms is difficult without an interdisciplinary team. We plan to bring on students from other disciplines to guide creative aspects of the work. Third, understanding, documenting and running code implemented by another developer continues to be slow. This experience will guide development of modules that can be studied with a shorter learning curve.

85
PI: Godmar Back
Institution: Virginia Tech
Project Title: Reinvigorating CS1 by Enabling Creative Web 2.0 Programming
Project Number: 0942762
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Introduction of Web 2.0-based Techniques for a CS1 course so students can learn basic computer science principles in the same environment in which most encounter them.

Methods & Strategies: Key is the development and evaluation of CloudSpace, a classroom tools used by us and made available to others.

Evaluation Methods & Results: Evaluation is based on surveys (done per semester) regarding student perceptions.

Dissemination: We have made available CloudSpace (http://cloudspace.cs.vt.edu/) and are working on a formal release announcement, to be distributed to SIGCSE mailing list.

Impact: Cloudspace has been very successfully used in our own CS 1114 course. Students are excited about the opportunities it provides, and how they can create 'real' apps very early on in their career.

Challenges: Producing the custom-published textbook volume for the course involved far more logistical headaches than expected.

86
PI: Ivona Bezakova
Institution: Rochester Institute of Technology
Project Title: Multiplayer Board Game Strategies in the Introductory CS Curriculum
Project Number: 1044721
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: (1) Develop CS2 projects based on existing well-ranked board games. (2) Motivate students to experiment and dive deeper into the course material, by asking them to implement strategies rather than the actual game logic. (3) Evaluate the performance of 'strategy students' vs. 'game logic students'.

Methods & Strategies: We use the 'learning in context' approach by selecting board games with high user ratings. The students implement their player strategy, using material learned in the course (e.g., search algorithms). We provide a game engine that calls the student strategy modules and displays the game.

Evaluation Methods & Results: For our first evaluation study (winter quarter 2011/12), we asked the students to fill out pre- and post-surveys, gauging their motivation and perceived competence using an adapted Intrinsic Motivation Inventory by Deci and Ryan. Out of 218 students who consented to the study, 66% agreed with 'I would describe the project as very interesting', 18% felt neutral, and 14% disagreed. For 'Doing the project made me feel more excited about computing', 53% agreed, 26% were neutral, and 20% disagreed. The student group consisted mostly of CS, SE, and CE majors.

Dissemination: We held a workshop for college and high school instructors in June 2011. We will hold another workshop in June 2012. We presented our project at two poster sessions: SIGCSE 2012 and OOPSLA 2011 (as part of their Educators Symposium). Several participants planned to use the project in their courses.

Impact: This project is a required component in our CS2 course, taken by about 300 students in the winter quarter, and additional 80 students in the spring quarter (9 sections in total) each year. Typically about six instructors are involved. The first project assignment is individual and the subsequent assignments are in pairs, allowing for over a 100 player strategies in the end-of-term tournament - a fun social event.
Two of the 2011/12 instructors are co-PIs on this award - the project materials are developed by the PI team, the other instructors are not involved in the development.

**Challenges:** We encountered technical challenges with Python/Pyglet/Cocos (the last two are for graphics) installation on some student computers (typically computers that were configured in a non-standard way). We were able to resolve all these issues. We are aware, however, of possible problems at other institutions that adapt our materials. We created a website with a sequence of steps to take to install the software successfully. The problems arose due to incompatibility of Pyglet/Cocos with the latest version of Python. We are currently looking at better solutions to this problem (possibly utilizing Java).

**87**

**PI:** Sergey Bratus  
**Institution:** Dartmouth College  
**Project Title:** SISMAT-Secure Information Systems Mentoring and Training  
**Project Number:** 0941836  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Our goal is to help nurture a security mindset among undergraduates from liberal arts institutions who may not have much access to research groups and facilities specializing in computer security.

**Methods & Strategies:** We have designed a comprehensive training, research, and experience program; it includes a 2-week seminar crash course in security, a summer internship, and a follow-on research project. We employ the principles of the ‘hacker curriculum’ to help students learn how to understand the inner workings of systems and networks.

**Evaluation Methods & Results:** Our evaluation plans focus on two main parts: (1) pre and post knowledge tests for student participants in the seminar and (2) follow-on surveys and tracking of the students as they enter careers in information security or go on to graduate programs in security.

**Dissemination:** We have organized two BoFs at SIGCSE; we have published two papers on our approach. We have designed and written a laboratory manual based on notes from the 2011 SISMAT session; we will be epublishing that and making it available as a wiki hosted on Dartmouth’s workspace.

**Impact:** The SISMAT program is a vital program that helps keep the expertise available to Dartmouth’s ISTS fresh and current on cutting edge information security topics. We’ve had a number of past participants go on to jobs and graduate school in information security programs.

**Challenges:** We have faced two challenges: recruiting for internship sponsors and recruiting students. We have mostly relied on personal professional contacts to fill the former gap. We have examined our student recruiting methods and determined to go on a tour of personal visits in addition to relying on past participant institutions, word-of-mouth, and distribution on SIGCSE mailing lists.

**88**

**PI:** David Bunde  
**Institution:** Knox College  
**Project Title:** Collaborative Research: Responding to Many Core: Teaching Parallel Computing With Higher-level Languages and Activity-based Laboratories  
**Project Number:** 1044299  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Increasing CS graduates ability to write parallel programs. We will develop materials using examples with wider student appeal using parallel programming languages with high-level constructs so students can focus on concepts with less code.

**Methods & Strategies:** We utilize summer students to examine languages, write sample code, and draft materials. The collaboration between colleges allows us to try preliminary materials on each other’s summer students and test the portability of our materials.

**Evaluation Methods & Results:** We collect qualitative feedback from summer students. We are developing surveys to collect qualitative and quantitative (Likert scale) data on student motivation and self-assessment of learning. We will examine student work to assess the quality of our materials and use interviews (some by the outside examiner) to identify misconceptions about or hidden prerequisites to the material taught.

**Dissemination:** Materials created so far are online. We participated in a CS education conference with a panel and a poster. We submitted a paper to an educational journal and have proposed tutorials on specific languages to two CS conferences.

**Impact:** Faculty in both our departments are trying our materials this term, one by guest lecture and one by teaching the materials himself. Exposure to our summer students’ talks also led a physics professor to start collaborating with one of us on using parallel computing in his research. Students at both institutions have demonstrated excitement about parallel languages, which we plan to convert into mastery of high-level concepts and specific parallel technologies.
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Challenges: We've had a couple of minor miscommunications because we've been operating fairly separately. We have started talking more regularly (Skype makes it relatively easy).

89
PI: Yuanfang Cai
Institution: Drexel University
Project Title: Contemporary Canonical Software Courses
Project Number: 0837665
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We aim to develop and offer courses introducing the architectures of two dominant open source systems: Firefox and Apache, and the interaction between them, because these two systems represent modern canonical distributed, multi-platform, and multi-language systems.

Methods & Strategies: Our methods are: (1) organize the key knowledge, as well as how Firefox and Apache relate to this knowledge, into slides; (2) develop a teaching tool to illustrate their architecture; and (3) design lab assignments that require students to build lightweight web browsers and web servers.

Evaluation Methods & Results: As a phase I project, our evaluation plan is informative and preliminary. We plan to (1) have our learning material evaluated by the key architects and major developers of Firefox and Apache; (2) have external evaluations by our industry partners who are the potential employers of our students; (3) evaluate the teaching results internally using the standard evaluation method in the College of Engineering at Drexel.

Dissemination: We have published papers on major software education and software engineering conferences. We will submit materials for inclusion in online repositories such as the Computer Teaching Center (CSTC), and the Computing and Information Technology Interactive Educational Library.

Impact: The teaching package developed in this project is applicable to the computer science or software engineering curricula of other universities and colleges. The package will contribute to modern computer science and software design knowledge base. Students equipped with the fundamental knowledge have the potential to be better prepared to make contributions to society in the Internet era. The course development stage encourages student participants to analyze and model the canonical systems, to develop the education tool, and to write papers and attend professional conferences.

Challenges: The analysis of Firefox is unexpectedly hard because (1) the project is undergoing modularity decay itself; (2) the project is too large and most research tools can’t process it.

We ended up having to develop our own reverse engineering tools.

90
PI: John Chandy
Institution: University of Connecticut
Project Title: Exploratory Curriculum for Trustable Computing Systems Security Education
Project Number: 1044313
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The principal goal of this project is to provide a novel approach to computer systems education by introducing a course in hardware hacking of computing systems. The expected outcome is more experienced computer engineering graduates by virtue of their hands-on experience in this program.

Methods & Strategies: The project introduces two new courses on Hardware Security, a junior-level Hardware Hacking class that reinforces computer engineering principles by teaching techniques to attack computer systems hardware, and a senior-level course that introduces more advanced hardware security technologies.

Evaluation Methods & Results: We are conducting the first course presently and have not yet obtained any data. We will be surveying students who take the two classes in the program to determine the skills that they have learned as a result of the program. These students will then be compared with other computer engineering students who have not taken the course, to determine the effect of the hardware hacking program. The expectation is that students who are in the program will have demonstrated a higher level of understanding of core computer engineering fundamentals.

Dissemination: The course material will be made available on the instructor’s websites for dissemination as well as the NSF-funded TrustHub website (www.trust-hub.org). In addition, the observations and knowledge gained from the program will be published in appropriate venues.

Impact: The project is still in its early stages, so we have not realized its potential impact. We anticipate that students who participate in the project will have a better understanding of core computer engineering concepts because of the hands-on aspect of the course and the notion that hacking requires a better understanding. We anticipate as the course gains greater awareness, the department will also see expanded enrollment in the computer engineering program.

Challenges: We expected larger number of students to enroll in our new course, but because the UConn computer engineering
curriculum has very few elective slots, not as many students signed up for the course.

**91**

**PI:** Ping Chen  
**Institution:** University of Houston-Downtown  
**Project Title:** An Interactive Undergraduate Data Mining Course with Industrial-Strength Projects  
**Project Number:** 0737408  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The objectives are: promote data mining skills essential to problem solving, apply data mining techniques to real-world applications, and establish vehicles and approaches to increase student retention in the course.

**Methods & Strategies:** The objectives will be accomplished in several ways: designing a pre-assessment instrument measuring student knowledge of data mining, and on-line tutorials; adapting course materials that will enhance problem-solving skills through reflection, critique, exercises, discerning theory from practice; develop interactive and animated courseware to help undergraduate students understand the harder concepts and algorithms.

**Evaluation Methods & Results:**  
We conducted evaluations based on students surveys, here are the results:  
- Question Fall 06 Spring 09 Spring 10  
- Assignments and projects were helpful. 2.83 4.37 4.22  
- I would recommend this course to fellow students. 3.00 4.25 4.33  
- I become more competent because of this course. 2.83 4.25 4.33  
- Course activities were well organized. 3.66 4.50 4.22  
- This course challenged me intellectually. 3.66 4.62 4.11

**Dissemination:** We have published several papers to disseminate our results:  

We also set up a website at cms.uhd.edu/faculty/chenp/class/4319 to disseminate our results.

**Impact:** University of Houston (UH) Downtown is a Hispanic-serving minority institution and UH also has large numbers of underrepresented minority students. Thus, the project trains and involves diverse populations of students. To students this project enhances student learning and experience by increasing visualization, interaction for the harder concepts through the adaptation and integration of the hypertextbook concept. Moreover our project exposes students to current and significant real applications of these concepts by designing industrial strength projects with the help of domain experts.

**Challenges:** Some data in real world projects is hard to obtain due to certain government/company restrictions. Instead we adopt real data from public domain with the help of our industry experts.

**92**

**PI:** James Cross  
**Institution:** Auburn University  
**Project Title:** jGRASP: Toward Effortless Program Visualization with a Canvas of Dynamic Objects  
**Project Number:** 0920632  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The jGRASP canvas (1) will successfully integrate pedagogically sound visualizations, (2) will be comprehensive enough for use in the target courses, (3) will be used at participating schools, and (4) will have a positive effect on students’ knowledge, skills, and behavior.

**Methods & Strategies:** Visualizations will be generated directly from the student's program before, during, and after its execution. A structure identifier mechanism will facilitate the automatic generation and rendering. The canvas will allow the user to combine multiple objects and primitives into a single unified view then save and reuse it.

**Evaluation Methods & Results:** Evaluation will be done during the of the last semesters of the project, which should be in summer or fall 2012. This will be an evaluation of utility and effectiveness, i.e., how effective and to what extent jGRASP is being used in computing curricula. We will track actual use by faculty and students in computer science courses using data reported by jGRASP itself with the user’s permission. Finally, we will have faculty and students complete a survey instrument to assess how well jGRASP met the outcomes described above.

**Dissemination:** Dissemination of information about the jGRASP canvas and distribution of the software will be done via the Internet, conferences, workshops, and publishers. The project web site (www.jgrasp.org), which contains information regarding the current version of jGRASP, will be upgraded for the new canvas.
Impact: We anticipate that this project will develop and deliver an innovative teaching tool for computing courses, the jGRASP canvas, that supports program visualization, which we know to be an effective teaching and learning aid based on prior experience and empirical evaluation. By generating dynamic visualizations of a student’s own program, the canvas is expected to facilitate clearer understanding by the student of the his/her executing program.

Challenges: Our first canvas prototype used a request-driven architecture, which was inherited from our previous viewer architecture. This posed an unexpected problem for our structure identifier (SI) viewer. A new mechanism has been implemented and all of our existing viewers including the structure identifier viewer have been modified to be compatible with it. Both of these necessary tasks involved a considerable amount of work. The current implementation is now at the point where we have a working canvas that may contain multiple viewers. We are now focused on improving the generated visualizations.

93

PI: Kostadin Damevski
Institution: Virginia State University
Project Title: Longevity-Oriented Curriculum Enhancement for Cyber-Physical Systems
Project Number: 1044841
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Our project’s primary goal is to prepare computer science students to contribute to the development of future applications that involve cyber-physical systems.

Methods & Strategies: The goals of our project will be accomplished through a set of course modules capable of engaging students in the concepts of cyber-physical systems. The course modules will be integrated in courses across the computer science curriculum, enriching student knowledge over their entire course of study.

Evaluation Methods & Results: We plan to begin evaluating our course modules during the next (Fall 2012) semester. Our intent is to use both direct and indirect measurements of student learning. As a direct measurement, we will compare relevant exam or homework scores between students that have used the course modules and those that did not. The indirect measure will be a survey of student knowledge, expectations, and excitement, conducted both before and after the use of our course modules.

Dissemination: We identified a set of five university faculty members interested in using our cyber-physical systems course modules in courses they teach. Each of them has agreed to evaluate our course modules, provide feedback, and, if appropriate, use one or more course modules in their courses.

Impact: So far, our TUES project has resulted in the submission of paper surveying middleware techniques for cyber-physical systems to the Journal of Systems Architecture. As our project progresses, we will continue to publish techniques, tools, and educational outcomes of our project in relevant journals and conferences. At the project’s completion, we will have produced a complete set of course modules that will become an ongoing part of our institution’s program of study. By collaborating with faculty at other universities, we plan to disseminate and enhance the course modules.

Challenges: To this point, the development of the initial set of course modules has proceeded smoothly and without any unexpected challenges.

94
PI: Peter DePasquale
Institution: The College of New Jersey
Project Title: COMTOR: Enabling Students and Educators to Automatically Assess Software Documentation and Source Code Comments
Project Number: 1044598
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: COMTOR will automate and reduce the effort of grading comments. At the same time, the use of COMTOR will give students a feedback process which allows them to self-assess the quality of their comments before submitting assignments for grading. A comprehensive assessment will determine whether the quantity and quality of commenting improves with the use of COMTOR as well as establishing whether advanced or introductory programming students benefit more from its use.

Methods & Strategies: Use of the system during student system use and on baseline student source code where the system was not used. Also surveying faculty and students on attitudes and practices of source code commenting.

Evaluation Methods & Results: We will be evaluating faculty in-class commenting practices (grading, pedagogy) via a faculty survey. We are also using the system in baseline analysis (w/o student use) and also with students using the system to determine if/how the system affects commenting coverage, quality, engagement with source code.

Dissemination: Have already given four invited talks on the project at four institutions, participated in the NSF showcase, presented a poster on the project (won best poster award), and have migrated the project to the cloud for widest possible dissemination of software and scalability of same.
Impact: COMTOR will impact students by providing an automated mechanism for assessing source code commenting, for faculty to grade comments, for as a clearing house for both students and faculty for motivation and best-practices for source code commenting. As of this application we are in the 1st year of the project.

Challenges: None as of yet.

95
PI: Matthew Dickerson
Institution: Middlebury College
Project Title: Teaching Computational Thinking Through Multi-Agent Simulation:
Increasing Recruitment, Retention, and Relevance of Undergraduate Computer Science
Project Number: 1044806
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Goals: 1) Recruit and retain computer science majors; 2) Improve preparation in computational thinking among students in other STEM disciplines. Intended outcome: a complete, transferable curriculum for a new introductory computer science class, based on multi-agent simulation and the NetLogo language.

Methods & Strategies: Use multi-agent simulation to teach computer science in a way that is relevant, especially to female students for whom a traditional introductory approach is too abstract. Use the NetLogo language to implement computational thinking concepts while enabling introductory students to create sophisticated simulations.

Evaluation Methods & Results: The project has finished year 1 of 3. The curriculum and materials are well-developed and ready for dissemination. The course has been taught once at the PI’s institution as a CS0/CS1 class, and once at another institution in a CS0 context. However, data collection is incomplete, and interpretation preliminary, based on pre- and post-course surveys designed to evaluate the class retention effectiveness, and from enrollment and retention information collected from tracked registration data. Positive results include a 50%-female enrollment and some successful recruitment of new majors.

Dissemination: The PI has presented workshops at a regional computer science conference for undergraduate faculty and a guest-lectured at a large university. He will continue to make materials available online and through workshops. When sufficient data has been collected, he will also seek to publish evaluation results.

Impact: The full impact of this early-stage project has yet to be realized. However, after the material was presented in a Fall 2011 workshop, the course was adopted at another college for Spring 2012, using material developed through this grant. The PI’s home institution has revised its major to incorporate this approach to introductory computer science. The newly developed course attracted 50% female students in the first semester. The PI expects his material to be adopted at a variety of institutions and to prove effective in providing a strong background in computational thinking to many previously unreached students.

Challenges: The course was taught in its first incarnation in Spring 2011 at the PI’s home institution, but will not be taught again until the Spring 2013. This will prevent the PI from collecting sufficient evaluation data until that time. Collecting comparable data at other institutions that use the material may be difficult.

96
PI: Heidi Ellis
Institution: Western New England University (formerly College)
Project Title: HumIT: Student IT Services to Support Open Source Software for Humanity
Project Number: 0940893
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The HumIT project focuses on using students to provide IT infrastructure services in the support of humanitarian open source software (H OSS). The project has two main goals: 1) the development, packaging and distribution of instructional materials to support instructors in applying the HumIT approach; and 2) the preparation of instructors for student delivery of IT services for HFOSS projects.

Methods & Strategies: HumIT initially investigated appropriate student learning activities related to HFOSS IT support. When it became clear that there are significant difficulties in having students provide IT services for end users, the focus was shifted to the investigation of student IT support for the HFOSS project itself. A workshop was held for to develop course materials and to prepare faculty members to teach courses in which IT students support HFOSS projects.

Evaluation Methods & Results: Evaluation has focused on the opinions of faculty members involved in the workshop on in involving IT students in HFOSS projects. Initial results indicate that faculty are excited by the potential of the HumIT project. In addition, the workshop was helpful in providing faculty members with an understanding of the learning opportunities afforded by student participation in an HFOSS project.

Dissemination: Dissemination of materials is done via a web site: xcitigroup.org/humit A workshop in summer 2011 lead faculty in developing materials to involve IT students in HFOSS. A second workshop is planned for fall 2012. The HumIT project
has been and will be presented in posters and panels at multiple conferences.

**Impact:** Faculty members are excited and attracted by the opportunities for IT student learning via providing support for HFOSS projects. 82% of attendees were inclined to introduce student HFOSS activities in their classroom. Materials identified during the spring 2011 workshop have been used in computing courses in several academic institutions. There is a growing community of instructors who are involving students in free and open source projects (Teachingopensource.org).

**Challenges:** Many faculty members have no direct experience in supporting a real-world project. As a result, many faculty members have concerns about the time and effort required to involve students in supporting an HFOSS project. A second challenge is raising awareness in the computing education community of the range of teaching materials and of the learning possibilities resulting from involving IT students in HFOSS projects.

**97**

**PI:** Alessio Gaspar  
**Institution:** University of South Florida Polytechnic  
**Project Title:** Do you have a CLUE: C Learning Undergraduate Environment  
**Project Number:** 0836863  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** This project focuses on helping novice programmers overcome the difficulties associated with learning the C programming language. Our contributions support both supervised learning environment, e.g. classrooms/online education, but also self-study.

**Methods & Strategies:** These goals are achieved by delivering a 3 weeks long self-paced online tutorial, a new peer programming pedagogy, & a novice-friendly IDE which features automatic novice errors detection along with tutorials to disambiguate compiler error messages.

**Evaluation Methods & Results:** Evaluation relies on students' grade, submitted assignments, software usage logs and attitude surveys. The latter explore the students' perception of the learning barriers we identified in terms of relevance to their own experience, the suitability of our solutions' principles, their implementation's usability. In addition, two psychometric instruments are used along with general workload surveys. This broad range of data sources allows us to go beyond assessing success/failure but profile the type of students who benefit from our interventions.

**Dissemination:** Dissemination of all deliverables on the project's site will be completed by summer 2012. Publications being submitted this semester will be added as they are published. Both tools and pedagogies will have been evaluated for one year in USF’s CS and potentially IT Departments. A workshop proposal will be submitted to SIGCSE in 2013 and will be advertised at the CCLI conference to maximize attendance.

**Impact:** The online modules allow instructors to let higher level courses' students, e.g. operating systems, learn C on their own over a period of three weeks. The material might also be reused in regular programming classes using this language. Our IDE's impact is to support the pedagogical innovation aspect of our work: introducing a constructivist dynamic in peer programming exercises in order to improve on the pair programming foundations.

**Challenges:** From a technological perspective, our software infrastructure has undergone several re-designs leveraging integration of existing open source projects in both client and server-side components of the project. From a pedagogical perspective, the difficulty of engaging students in collaborative programming activities in an online asynchronous course has been addressed by the design of constructivist peer programming activities.

**98**

**PI:** Swapna Gokhale  
**Institution:** University of Connecticut  
**Project Title:** Integrating Open Source Software into Software Engineering Curriculum  
**Project Number:** 1044061  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of the project is to develop a methodical approach to integrate open source software projects into software engineering curriculum.

**Methods & Strategies:** The initial approach is to manually select suitable projects for integration. Subsequently, we will study these projects and their metrics for the development of predictive selection models for methodical integration.

**Evaluation Methods & Results:** Evaluation methods include anonymous pre- and post-semester surveys and participant observations. The evaluation results from one semester show that the students appreciate the extensive role of software maintenance and evolution in the software lifecycle. They also demonstrate maturity in using software engineering concepts, as opposed to just programming-centric language.

**Dissemination:** Presently, the dissemination is in the form of research papers at appropriate computing education conferences and journals. We also plan to organize a workshop on open source software in software engineering education.
**Impact:** The project may revamp/change the way software engineering classes are offered; open source software may become an integral part of these offerings.

**Challenges:** During the manual selection of open source projects, we encountered several difficulties because the small projects, which we believed to be within the scope of our students could not be compiled easily, included documentation and variable names in languages other than English. Moreover, the open source tools installed for experimentation ran into unexpected difficulties.

**99**  
**PI:** Jesse Heines  
**Institution:** University of Massachusetts Lowell  
**Project Title:** Computational Thinking through Computing and Music  
**Project Number:** 1118435  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise  

**Goals & Intended Outcomes:** Our goal is to disseminate ways to enhance students' grasps of CT by engaging them in fundamental concepts that unite computing and music. Our approach leverages students' near universal interest in music as a context and springboard for engaging in rich computational thinking experiences.

**Methods & Strategies:** We share our techniques through sponsored workshops which participants attend as a pair: one from a science or engineering department and the other from Music or another arts department to ensure that collaborations begun in the workshops will be sustainable on return to their own institutions.

**Evaluation Methods & Results:** Evaluation will be achieved through course surveys, participant follow-up surveys, and faculty interviews. We will attempt to do evaluation directly after each workshop and then follow up with participants later in the year. We will also attempt to do some student-centered evaluation to determine the effect of our interdisciplinary courses on student attitudes.

**Dissemination:** We currently have three workshops scheduled. Our pilot workshop took place on April 27th with ten participants. Our full two-day June 21-22nd workshop is 'sold out' with 28 participants. Our January 17-18th, workshop already has ten registrants. We are scheduling other workshops, as well.

**Impact:** We expect most impacts to be outside of our own departments due to long-standing cultural issues that make interdisciplinary teaching in our departments more of an individual professor effort than a coordinated departmental one. Our workshops are being enthusiastically received by professors from a wide variety of disciplines, and approximately 20 pairs of professors have already registered for them. Thus, we expect our work to have more impact at these professors' institutions than our own.

**Challenges:** We are in the early stages of our project and have not yet encountered any major challenges other than scheduling.

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**100**  
**PI:** Gregory Hislop  
**Institution:** Drexel University  
**Project Title:** SoftHum: Student Participation in the Community of Open Source Software for Humanity  
**Project Number:** 0958204  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** SoftHum attracts students to computing by supporting student involvement in and contributions to Humanitarian Free and Open Source Software (HFOSS) within courses. SoftHum develops means to support student involvement in HFOSS within courses.

**Methods & Strategies:** Student excitement about contributing to a real-world project engages them in computing. SoftHum supports instructors who want to involve students in HFOSS by investigating, documenting and developing course materials and infrastructure.

**Evaluation Methods & Results:** Evaluation has investigated opinions of students and instructors who participate in an HFOSS project within a course. Results show that an infrastructure supporting HFOSS in the classroom successfully supports learning, the humanitarian nature of HFOSS has an affirmative impact on student perception of computing, and participation in an HFOSS project has a pronounced positive impact on students' view of computing, especially less experienced students.

**Dissemination:** Dissemination of materials is done via a web site: xcitegroup.org/softhum Workshops in 2009 and 2011 lead faculty in developing materials to involve students in HFOSS. SoftHum has also been presented in papers and panels at multiple conferences.

**Impact:** Students are excited and actively seek to participate in HFOSS projects. Faculty members have used or intend to use materials generated from SoftHum in courses. The project has influenced other local academic institutions to involve students in HFOSS.

**Challenges:** Faculty members appear to have greater than expected concerns about involving students in ongoing software projects. More attention has been paid to defining methods of evaluating and gaining entrance to HFOSS projects,
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documenting a wide variety of ways for students to participate beyond coding, and providing a set of online resources.

101
PI: Joseph Hollingsworth
Institution: Indiana University Southeast
Project Title: Hands-On Collaborative Reasoning Across the Curriculum - Phase II
Project Number: 1022191
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Our primary goal is to develop and distribute learning modules that faculty can use to teach the basics of these software-proving techniques in various classes across the undergraduate curriculum.

Methods & Strategies: We have created instructional materials based on performance-based learning outcomes that include lecture notes, handouts, worksheets, videos, and assessment tools. We have disseminated these through workshops and conference presentations, and direct communication via the Internet.

Evaluation Methods & Results: Performance-based learning outcomes (LOs) describe using action verbs what a student must do to demonstrate understanding. We have used these LOs to develop various assessments, e.g., labs, quiz questions, in-class group work, and test questions. We have gathered and analyzed data based on these assessments from our own classes as well as from other faculty members at other campuses. Results have shown where we need additional or better instructional materials, as well as that students can learn software-proving techniques.

Dissemination: We have disseminated these through workshops and conference presentations, and direct communication via the Internet.

Impact: These software-proving techniques empower students to systematically reasoning about its behavior, as opposed to using a guess and check method. We know that complete formal reasoning about software is still in the future, however, learning these fundamental techniques allow students to more effectively reasoning at an informal level. The work cuts across many Knowledge Areas (Computing Currricula 2013), faculty are seeing new ways to tie what they are teaching in one class (e.g., logic in discrete math) to other CS classes (e.g., software development, data structures, etc.).

Challenges: Our number one challenge appears to be faculty who see the benefit of this approach, and want to adopt items from our learning modules, but are just too busy find ways to integrate these instructional materials. We're exploring ways to provide mini-grants to these faculty as a way to incentivize the adoption of various instructional materials.

102
PI: Dijiang Huang
Institution: Arizona State University
Project Title: A Cloud-based Resource and Service Sharing Platform for Computer and Network Security Education
Project Number: 0942453
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The project is to establish an online lab (V-Lab) that provides a flexible and configurable cloud-based virtual computing and networking environment for hands-on networking and security assignments and projects. V-Lab allows students to perform assignments and projects without physical and time restrictions and can greatly improve educational quality and encourage curriculum sharing.

Methods & Strategies: The V-Lab is established based on advanced virtualization technologies that can help students to deploy real networking systems in a virtual environment. Students can request resources to customize their desired experimental setup in real-time and virtual LANs are set up to isolate students' deployments. Laboratory-based curriculums are designed to foster the online education.

Evaluation Methods & Results: The learning curve for V-Lab is evaluated for groups of students who do not have any experience of V-Lab before. The results show the learning curve for the system is less than 5 minutes on average. After each lab, a survey is collected from students with designed single-choice questions covering six educational factors: motivation, knowledge, creativity, collaboration, demonstration and feedback. The survey results showed that students were more motivated to perform course projects due to easy use and management of the lab setup. Moreover, the results showed that students had better understanding of related materials compared to students who did not using the system. Furthermore, the deployed web 2.0 technologies allow students to share and collaborate with each other and improve communication between students and instructors.

Dissemination: The project is originally designed for supporting computer network security courses. We had disseminated the results within the ASU education environment. For now, more than 6 computer science and engineering courses had used the lab for their courses. We plan to incorporate more universities to use the system in the following semester.

Impact: V-Lab helps students to better understand the related course materials. Moreover, it significantly reduces the complexity of running a physical lab, investment cost, and management overhead. The system saves both time and space.
for students and instructors on setting up a traditional laboratory. For example, V-Lab helps restore the laboratory to its previous setup after a system failure caused by misconfigurations and malfunctions. V-Lab helps students collaborate and demonstrate in the class and improves communications with instructors. V-Lab helps students and faculties start research-oriented projects, and some of which had developed into research articles. The school of engineering had decided to adopt V-Lab and use it for a broader range of courses.

**Challenges:** To create virtual resources and automatically construct virtual private networking systems, a great deal of development and research need to be performed such as establishing automatic, reconfigurable, and programmable interfaces for virtual machines, networking interfaces, IP addresses, port mapping, databases, etc. The team had to investigate and develop new virtual resource management approaches to address these issues. The system reliability is another challenge. To address this problem, we had developed backup and recovery solutions. Finally, to evaluate the performance of the system in terms of improving the education quality, we had devised a set of survey questions and performed comparative studies.

**103**

*PI:* Wei Jin  
*Institution:* Shaw University  
*Project Title:* A Cognitive-Apprenticeship Learning Curriculum Augmented by Cognitive Tutors (CAL-CT) for Fundamental Programming Concepts  
*Project Number:* 837505  
*Type:* Phase 1/Type 1 - Exploratory  
*Focus:* Creating Learning Materials and Teaching Strategies

*Goals & Intended Outcomes:* This project addresses the fundamental and intrinsic learning difficulties with programming. The goal of this project is to develop a set of online cognitive tutors to address student learning obstacles in introductory programming courses, initially in a Historically Black Colleges and Universities (HBCU) and later extended to other institutions. The intended outcome is that students who utilize cognitive tutors will demonstrate problem-solving competence with fundamental programming concepts.

*Methods & Strategies:* This project utilizes two instruction methodologies: 1) cognitive apprenticeship learning (CAL) and 2) cognitive tutors (CT). First, detailed analysis of how experts solve problems is conducted and scaffolding techniques to assist student learning are developed. Second, computer tutor programs based on the process and techniques from step 1 are constructed and delivered online.

*Evaluation Methods & Results:* The CAL-CT, CAL-only and no-CAL approaches are evaluated using statistical analysis of collected posttests and student attitudinal surveys. Effectiveness of the CAL-CT approach for students with different GPAs was also studied. On average, test scores for students in the CAL-CT group are 53% higher than students that benefitted from CAL-Only instruction and 64% higher than students in the no-CAL group. CAL-CT students tend to have a more positive attitude towards course activities. Students in the middle GPA range benefitted most from using automatic tutors. Students with lower GPAs displayed lower engagement in coursework, as indicated by their low scores for programming assignments that were fully guided by automatic tutors.

*Dissemination:* We have published at SIGCSE 2011 and ICER2011. We have given presentations at several schools about CAL-CT tutors and have generated interest. We are currently deploying and evaluating CAL-CT tutors at UNC-Charlotte. We will continue our efforts in recruiting beta sites. We have also planned a one-day workshop for HBCUs for summer 2013.

*Impact:* Both anecdotal evidence and collected data indicate improved student learning. After students used tutors for one concept, they often ask for tutors for other concepts. The majority of students said that these tutors helped make the course more enjoyable, helped them learn faster and at a higher level, and improved their motivation. A couple of faculty members at other STEM departments are interested in similar approaches in their courses. Faculty members from several other universities also expressed interest. Currently, we are deploying and evaluating the tutors at UNC-Charlotte and we plan to extend to more schools once a dynamic feature of the tutors is fully developed.

**Challenges:** One challenge we encountered recently is the evaluation of the tutors in a large public institution. Students' programming skills are evaluated using rubrics. It is labor-intensive; however, with a relatively small Computer Science department at Shaw University, it was manageable. With over 350 students in the introductory programming courses at UNC-Charlotte, rubrics based evaluation becomes a daunting task. We are planning to have a team of graduate students to assist grading these tests. Each test will be evaluated by at least two students to guarantee grading consistency.

**104**

*PI:* Anthony Joseph  
*Institution:* Pace University  
*Project Title:* Technology Entrepreneurship in Computer Science  
*Project Number:* 0942732  
*Type:* Phase 1/Type 1 - Exploratory  
*Focus:* Creating Learning Materials and Teaching Strategies

*Goals & Intended Outcomes:* To acquire the knowledge and skills in entrepreneurship and its application as well as to design/develop algorithms for financial and health informatics technology products, services, or processes; and to apply
computing theories and practices to other disciplines such as business and healthcare.

**Methods & Strategies:** These include teamwork, guest lectures, individual and team exams, class projects for student teams to develop unique solutions to human problems in finance or healthcare; use of mentors from industry to support individual teams with project; and project presentation and demonstration.

**Evaluation Methods & Results:** Evaluation methods include pre and post SALG surveys, team performance inventory, entrepreneurship test, exams, student aide survey, mentor survey, student survey, monitoring and support survey, interviews, conversations with students and mentors, journals, and team project scoresheet. In the offered courses, over 70% of the student teams and members demonstrated computing and related mathematics knowledge in the development of course projects as well as demonstrated and/or reported gains due to teamwork activities.

**Dissemination:** James Lawler and Anthony Joseph (April 2011). A Financial Technology Entrepreneurship Program for Computer Science Students, Information Systems Education Journal (ISEDJ), Vol. 9, No. 1, pp. 53-59. Also, two conference papers and a workshop were presented, and a project website was developed. More papers will be disseminated to the public via conferences and journals.

**Impact:** 1) Undergraduate students entrepreneurial tendency improved by 4%; 2) Students found that the Technology Entrepreneurship course opened their minds up to being innovative, creative, and an opportunity seeker and analyst; 3) Some students felt that the Technology Entrepreneurship course should be mandatory because of the positive impact and learning it had on them; 4) Students learned how to work effectively with others; and 5) Students found the mentors and guest speakers to be very helpful.

**Challenges:** Recruitment -- Although the recruitment campaign each semester targets undergraduate students in computing, business, mathematics, and science, most of the students who enrolled in the courses so far are computer science students. A more comprehensive recruitment campaign is being currently pursued more faculty and staff are asked to assist in advertising the courses to the students they interact with or have access to. This advertising is done over a longer period.

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**Goals & Intended Outcomes:** The goals are centered around teaching motion planning. We are developing a software tool, examining its the effectiveness for diverse learners at three institutions, and engaging a broad spectrum of faculty and students. Expected outcomes include increased adoption of the tool in robotics classes, teaching of advanced concepts, and improved student performance.

**Methods & Strategies:** We have created OMPL which implements advanced robotics concepts in a way that can be put together to build motion planners. Several planners have been implemented. We have also developed a series of assignments to scaffold learning. This is done in collaboration with several colleagues at other institutions.

**Evaluation Methods & Results:** The project is evaluated through surveys at several levels. First, students are surveyed a number of times during a semester. Assessments for all assignments are done. Second, the instructors at the partner institutions where the material will be used, are surveyed at the end of the semester.

**Dissemination:** So far 5 colleagues from different institutions have obtained our code, educational material and assessments. We are working with them for adopting our work during the 2012 academic year.

**Impact:** We have noticed that we can teach much more advanced concepts and push the students to complete projects that would have been simply impossible without the work of this project. Transfer of expert knowledge to novices is much more effective given our tools and the students are very excited to be able to tackle large projects, as indicated by the surveys. We expect that in the future this experience will be carried to students in other institutions and other colleagues.

**Challenges:** It has been a huge challenge to transfer expert knowledge to novices. As the concepts taught are advanced, we had to structure the software to build up knowledge. We had to parse down all individual components to avoid gaps in knowledge that would impede further learning. This required a huge collaborative effort among the PIs, the developers, the TAs, and the students.

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**105**

**PI:** Lydia Kavraki  
**Institution:** Rice University  
**Project Title:** Teaching Robot Motion Planning Through an Integrated Software Environment  
**Project Number:** 920721  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

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**Goals & Intended Outcomes:** The Security Injections@Towson project was designed to 1) increase the number of security-skilled students, 2) increase students' awareness of secure
coding issues, 3) increase students' ability to apply secure coding principles, and 4) increase faculty awareness of secure coding concepts.

**Methods & Strategies:** We use 'Security injections' that are topical modules that can be integrated into existing courses with little or no disruption to existing curricula. Injections are focused on the use of checklists that require students to examine code for potential security concerns, lab assignments that illustrate security issues, and discussion questions that encourage reflection.

**Evaluation Methods & Results:** Each of these objectives is assessed using various instruments including surveys, random sampling of assignments, qualitative inputs from faculty, controlled experiments in classrooms, and institutional quantitative data. Results show that security injections help students retain, comprehend, and apply secure coding concepts in the CS0 and CS1 introductory courses and increase students' security awareness in all computing courses.

**Dissemination:** We have conducted on-site workshops at each institution to introduce faculty to our modules and discuss the importance of this effort. Our website www.towson.edu/securityinjections serves as a dissemination method and we continue to organize birds-of-feather sessions at conferences and meetings with community colleges to disseminate modules.

**Impact:** Our faculty workshops have been attended by over 60 faculty and over 1,600 students have participated in the assessment of the injection modules.

**Challenges:** There is strong instructor inertia against adoption of security topics in lower level classes (due to excess subject matter, lack of security training, interest, or motivation). We have revised modules, dissemination methods, grading strategies and provided help in injecting material into course schedules for help in adoption.

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108
**PI:** Abdullah Konak  
**Institution:** Penn State Berks  
**Project Title:** Exploration of a Collaborative Virtual Computer Laboratory (CVCLAB) to Enhance Distance Learning in Information Security  
**Project Number:** 1044800  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The overall goal of the project is to enhance information security education by enabling students to practice important skills and to learn together both inside and outside the classroom using a virtual computer laboratory, with a particular focus on distance learning.

**Methods & Strategies:** We have created a collaborative virtual computer laboratory (CVCLAB) that seeks to leverage virtual computers together with specially designed exercises to create a learning environment for information security. We studied the impact of collaborative work on student learning in the CVCLAB.

**Evaluation Methods & Results:** To investigate the effect of collaborative work on student learning in the CVCLAB, we conducted a preliminary experiment where two groups of students performed two versions, group work (GW) and
individual work (IW), of the same activity. In both GW and IW treatments of an activity, students followed the exact same steps and were introduced to the exact same content, but students in the GW treatment had to work together for a successful completion of the activity. Then, we compared student learning experiences and outcomes using a research model based on Kolb’s Experiential Learning Theory (Kolb, 1984). A structural equation model was used to investigate the differences between the treatment groups.

**Dissemination:** A conference paper was accepted to AMCIS 2012. We organized a day camp for underrepresented K-12 students in the STEM fields. Two undergraduate students presented their research contributions in a regional research conference. Students from the Lebanon County Career and Technology will be using the CVCLAB and our hands-on activities in May 2012. A website was created.

**Impact:** So far, we received very positive responses from students and faculty although the project is still in its early stages. We designed and offered an online course based on the educational materials created. Two Penn State Campuses used the CVCLAB in three different courses. Students highly praised the hands-on activities and reported positive learning outcomes. Drexel University also studied the CVCLAB, we are helping them to design and implement a virtual computer laboratory. The project hired three undergraduate students who are engaged in undergraduate research activities.

**Challenges:** Two of the project senior personnel are not with the project due to new employment. In addition, we had changes in course schedules and assignments. Currently, the project is seeking to recruit new faculty members to test the outcomes of the project. A new faculty member volunteered to participate the project activities.

**109**

**Pi:** Amruth Kumar  
**Institution:** Ramapo College of New Jersey  
**Project Title:** The Next Generation of Practice Exercises for Computer Science I  
**Project Number:** 0817187  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The goal of the project is to help introductory Computer Science students learn programming concepts by solving problems. Its outcomes include 1) development of third generation problem-solving software modules that customize problems and provide simulative feedback in order to maximize student learning while minimizing their time and effort; 2) evaluation of the features that improve the effectiveness of problem-solving software modules; and 3) evaluation of the effect of using a suite of modules on the cumulative performance of introductory Computer Science students.

**Methods & Strategies:** The problem-solving software modules were built as Java applets that run in any browser, so that adopters can use them without any download or setup. Intelligent tutoring system architecture, model-based reasoning and object-oriented design principles were used for the development of the software modules, so that they would be reusable and composable. Each module administers pre-test-practice-post-test protocol, making it possible to collect evaluation data every time a student uses a module. The data is collected over the web and evaluated in batch mode. The grantee institution hosts the web site where all the software modules are posted (www.problets.org), as well as the mailing group used for dissemination.

**Evaluation Methods & Results:** The software modules continue to be evaluated in vivo. Controlled studies and partial cross-over design are used for evaluation. Results of evaluation include: 1) When error-detection support is provided to students answering an online test, their score increases significantly, even though no error-correction support is provided. One reason for this is that students save time on the problems they know how to solve and spend it attempting problems for which they do not readily know the solution. However, error-flagging encourages at least some students to engage in informed trial and error even though the problems are not multiple-choice in nature.

Finally, placing a limit on the number of revisions may discourage students from using error-flagging feedback as a substitute for their own judgment. 2) Stereotype threat applies to online testing in Computer Science - female and minority students score better if they are asked for their demographic information after rather than before using an online test. However, on harder topics in Computer Science, stereotype threat affects all the students, and in particular, the less-prepared students. 3) Treating demographic groups as homogeneous groups when evaluating educational interventions in Computer Science could miss subtle interactions that exist among the groups. 4) Reflecting on the concept underlying each problem does not promote greater or faster learning if the practice software already promotes deep learning. 5) Data space animation helps students learn the semantics of pointers. But, it is no more effective than text explanation, which is cheaper to produce. Results 1 and 2 have significant implications for online testing, result 3 on evaluation of educational software, result 4 on development of such software, and result 5 on problem-solving software for Computer Science.

**Dissemination:** Results from the evaluation of the software modules have been presented at the following conferences: FIE 08, Saratoga Springs, NY, SIGCSE 09, Chattanooga, TN, FLAIRS 09, Sanibel Island, FL, ITCSE 09, Paris, France, FIE 09, San Antonio, TX, ITS 10, Pittsburgh, PA, FIE 10, Washington D.C., Al-
ED 11, Auckland, NZ, FIE 11, Rapid City, SD, ITS 12, Crete, Greece and iTICSE 12, Haifa, Israel. The software modules were publicized in NSF booths at SIGCSE 09, SIGCSE 10 and SIGCSE 11 conferences. The project was written up in ACM Inroads magazine in December 2011 (Vol 2, No. 4). In addition, every semester, the software has been publicized on the SIGCSE mailing list and problets mailing list. A dedicated web site has been maintained and updated at www.problets.org.

Impact: The software modules have been used every semester since fall 04. They were used by 20 adopters in fall 08, 35 in spring 09, 29 in fall 09, 32 in spring 10, 39 in fall 10, 29 in spring 11, 41 in fall 11 and 43 in spring 12. 38% of the adopters are repeat users. The modules have been used in universities/4-year colleges, 2-year colleges and high-schools across the US and abroad. The impact of the project is best expressed in the words of students from various institutions, whose testimonials have been posted at http://problets.org/about/testimonial.html

Challenges: It has remained unexpectedly hard to find qualified students to work on the project because of declined enrollments and increasing demand in the industry for students with Computer Science background. As a result, the PI has had to do a lot of the software development himself.

110
PI: Stan Kurkovsky
Institution: Central Connecticut State University
Project Title: Using Mobile Game Development to Improve Student Learning & Satisfaction in Introductory Computer Science Courses
Project Number: 0941348
Type: Phase I/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The main goal of this project is to improve student success and satisfaction in introductory CS courses. This project will produce a set of learning modules consisting of laboratory projects and instructional materials that would use mobile game development early in the CS curriculum.

Methods & Strategies: We leverage mobile computing because student find it easier to relate to mobile technology. Mobile game development is used early in the CS curriculum as a learning context to reinforce student mastery of the core CS concepts and to introduce them to advanced CS topics.

Evaluation Methods & Results: Assessment activities include direct measures of student learning of CS concepts using locally developed pre- and post-tests. Following research that suggests effective educational design promotes attention relevance, confidence, and satisfaction, student motivation and engagement will be measured using modified versions of validated instruments in consultation with the project evaluator and the PIs teaching the courses. Instruments will be administered to a test group as well as to the control group. Qualitative feedback will also be collected using open-ended questions on written forms and/or focus groups.

Dissemination: We conducted a SIGCSE workshop in 2011 and offered 8 tutorials and workshops at a number of CCSC conferences.

Impact: This project will promote teaching and learning by creating curricular materials that are compelling and relevant to today’s students. This project will have a positive impact at the PI’s institutions, as well as at many other universities, colleges, and high schools that will be able to benefit from the results. Instructors without any prior experience in game development or mobile computing will be able to easily incorporate mobile game development projects into their courses. Produced learning modules will have very low technological and cost barriers to adoption.

Challenges: The challenges were mainly of a technical nature and were resolved early in the project.

111
PI: Barry Kurtz
Institution: Appalachian State University
Project Title: Developing Software and Methodologies for eBook/Browsers to Enhance Learning
Project Number: 1044572
Type: Phase I/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: (1) explore built-in capabilities of eBook/Browsers in and out of the classroom; and (2) design and implement software tools to enhance learning using mobile devices (3) design and implement web services to overcome inherent limitations of eBook/Browsers.

Methods & Strategies: (1) develop the Microlab approach that engages students in active learning during lecture and apply this approach to a variety of tasks (2) develop the Web-based Automated Grading System (WAGS) to expand the functionality of eBook/Browser devices.

Evaluation Methods & Results: We will use three techniques to evaluate the effectiveness of the microlab approach:

1. collect electronic data on how students used the microlab activities interactively
2. use written exams to collect data on student retention of the concept studied in the microlabs
3. use online surveys to determine student attitudes towards microlabs

Dissemination: This academic year our microlabs have been used in three courses at Appalachian State taught by four
Poster Abstracts

different instructors. Two outside universities, UNC Greensboro and UNC Asheville, are using the microlabs. This dissemination effort will be expanded dramatically next year.

Impact: We have used the microlab approach in four courses at Appalachian State: Computer Science 2, Data Structures, Programming Languages, and Parallel/Distributed Computing. The first three courses are required for all Computer Science majors. Students have reacted very positively to logical microlabs that introduce basic concepts conceptually. Use of programming microlabs where students implement the algorithms developed in the logical microlabs has proved to be more challenging.

Challenges: (1) Students are used to sophisticated IDEs such as Eclipse to enter program code; the simple text box environment in WAGS disappoints students. We have improved the entry of program code (e.g., allowing tabs) but will never match the sophistication of an IDE. (2) We are a small school and only teach one section each semester of the courses where microlabs are being used; this makes a control group and experimental group impractical. We are expanding our testing to larger schools next year.

112
Pi: Clifton Kussmaul
Institution: Muhlenberg College
Project Title: Process Oriented Guided Inquiry Learning (POGIL) in Computer Science
Project Number: 1044679
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The CS-POGIL project will develop, refine, validate, and disseminate process-oriented guided-inquiry learning (POGIL) materials in computer science (CS), for software engineering and data structures & algorithms. These materials will raise awareness and foster a POGIL community among CS educators.

Methods & Strategies: First, we create, review, and pilot materials, and assess them qualitatively. Second, we show materials via presentations and workshops, to obtain more feedback and recruit collaborators. Third, we refine materials, and assess quantitatively. Fourth, we push materials and POGIL to a broader community.

Evaluation Methods & Results: We will evaluate qualitatively early in the project and quantitatively later in the project. Student affective outcomes will be evaluated with instruments that are already in use at participating institutions, other existing (calibrated) instruments, and possibly instruments designed as part of this project. PIs & CS Collaborators will be evaluated with activity reports to track quantitative factors (e.g. # of activities reviewed, used, developed) and qualitative factors (e.g. attitudes toward teaching & scholarship).


Impact: The POGIL materials from this project will raise awareness and foster a POGIL community among CS educators, not just at one institution, and thereby improve the quality of CS education broadly. We are encouraged by the variety of interested collaborators.

Challenges: Scheduling difficulties with some collaborators (e.g. sabbaticals and summer travel) who have had to defer active participation (not a major problem).

More interest from varied collaborators, including high school teachers and faculty in southern India, so we need to balance initial and evolving objectives (this is a good problem to have).

113
Pi: Chengcheng Li
Institution: East Carolina University
Project Title: A Centralized Resource Management Model for Computer Networking Laboratory Equipment Sharing among Collaborating Institutes
Project Number: 0837722
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: 1). Create a DE laboratory environment that is equivalent to a face-to-face hands-on environment for the information and computer technology majors; 2). save lab space and equipment cost; and 3.) decrease management complexity by sharing centralized computing resources among collaborating institutions.

Methods & Strategies: Design, implement, and deploy a centralized reservation system that provides remote access to and manages computer networking labs in different geographic locations, consolidating isolated pieces of lab equipment. Develop network security curricula that are taught in the collaborative institutions. Create lab and lecture teaching environments that can be remotely accessed for teaching the security curricula.

Evaluation Methods & Results: A standard assessment instrument was developed from surveys, interviews, baseline data, and post-test only methods following the instruction listed on the ASEE publication on engineering education assessment. The quantitative data lead directly to the summative assessment of the specific outcome. The qualitative data can be combined
or transformed into measurable values to construct either summative or formative assessment. The assessment instrument was modified after each semester to insure continuous improvement. A comprehensive assessment will be conducted at the end of the project in spring 2013 before the PI conference. The majority of the 200+ students from three institutions surveyed agree that the innovative remote lab is better than the traditional physical lab in term of ease of use, accessibility, and added functionalities.

**Dissemination:** Two networking courses are redesigned and the accompanied virtual lab teaching environments have been developed and deployed at ECU. The central lab management system has been introduced to more than 30 institutions through two workshops and instructor training seminars. The outcomes are also disseminated through conference and journal publications.

**Impact:** This project directly impacted more than 200 students in the three collaborative institutions, in which, one is a HBCU and one is minority college with more than 97% Hispanic student population. Instructors from more than 14 colleges and local high schools participated in the summer workshop. The project produced a lab teaching environment, a central lab management system, security curricula can be disseminated nationwide. 2 journal and 4 conference papers have been published. The project received an industry equipment donation from HP Catalyst Initiative program with market value of $170,000. The outcomes from the project were disseminated through conferences and academic seminars such as Sloan-C online seminar and HP Summit. More than 20 institutions worldwide have expressed great interests to host their remote teaching environments in our system and collaborate with us.

**Challenges:** Constant and frequent updates of the virtualization technologies keep our IT staff busy maintaining the system. The good news is that the VCL system becomes more mature; and the installation and configuration process are simplified. The PI attended the IBM Cloud Academy conference in 2012. The IBM supported VCL is broadening its impact in academia.

We are also migrating our virtual labs from VCL to the VMware vCenter Lab Manager system for better technical support. The concurrent run of both VCL and Lab Manager systems greatly improved the availability of the student remote lab. But this approach increased the faculty and IT staff’s workload. As more institutions tried out our system for their remote teaching, the computing capacity limitation of our hardware was reached. We reached out for industry support and received a one-time equipment donation from HP for blade servers and laptop computers. The donation greatly improved our capacity to support more collaborating institutions.

**114**

**PI:** Susan Lincke

**Institution:** University of Wisconsin-Parkside

**Project Title:** Information Security: Audit, Case Study, and Service Learning

**Project Number:** 0837574

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The Development of the Small Business Security Workbook, for use with Service Learning. Students use the Health First Case Study to practice before working with a real community partner.

**Methods & Strategies:** The lecture and workbook materials are taken from professional sources: ISACA’s Certified Information Systems Auditor (CISA) and Certified Information Security Manager (CISM). The case study also deals with HIPAA regulation.

**Evaluation Methods & Results:** The most useful evaluation methods include:

1. Weekly student evaluations on lecture/case study,
2. Service learning evaluations from students, community partners,
3. External evaluator discussions with students.

Our results show that the Workbook was immediately and easily accepted by community partners, students, and security professionals. It has been a challenge for the case study to become as successful, but with many improvements, success is being achieved.

**Dissemination:** Dissemination has been to teaching conferences, professional workshops, and research conferences, through publications, tutorials, posters, and presentations. This year is our fourth (extended) year, when most dissemination is occurring.

**Impact:** The project has been adopted by two other Chicago-area universities (that the PI is aware of). It is being tried out in an MBA program at UW-Parkside. The PI is teaching a short course in Germany also. Of our five community partner organizations that used this Workbook with student guidance, 100% were very satisfied with the quality of students’ work.

**Challenges:** Unexpected challenges included:

1. Change in instructor partners (successful change occurred)
2. Making the case study successful required many improvements
3. Too many assessment techniques resulted in some techniques suffering low student participation.

The difficulty with the case study meant that dissemination was delayed one year. Also, the more stable Small Business Security Workbook was distributed via paper, since the other materials were in fluctuation.
**115**

**PI:** Natarajan Meghanathan  
**Institution:** Jackson State University  
**Project Title:** Incorporating Systems Security and Software Security in Senior Projects  
**Project Number:** 0941959  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of the project is to incorporate aspects of systems and software security into senior capstone projects. The intended outcomes are: (i) Students incorporating security aspects into all phases of their software development lifecycle; (ii) Development of lecture modules and project descriptions that can be adopted by non-security instructors; (iii) Development of new security-related elective courses and (iv) Enhanced lab support to conduct senior capstone projects.

**Methods & Strategies:** (i) The PI and Co-PI effectively integrated the security modules into the regular software engineering lecture slides and taught to the students; (ii) Two new elective courses (Systems and Software Security; Advanced Information Security) were developed and offered. The junior and senior students, especially those involved in the capstone projects are encouraged to take these courses; (iii) Several lecture modules, lab project descriptions and sample questions have been developed for various topics on systems and software security and disseminated online; (iv) Students were taught about virtualization and taught to run their security-related code modules in a virtual machine environment.

**Evaluation Methods & Results:** The incorporation of the security aspects in the senior capstone projects is evaluated through direct and indirect methods. Several student learning outcomes related to security were infused into the syllabus for the CSC 475 Software Engineering and CSC 450 Senior Project courses. The direct method is the Faculty Course Assessment Report (FCAR) prepared by the instructor of these courses at the end of the semester assessing student performance on questions in the security modules and the incorporation of security aspects. The indirect method involves surveys conducted with students on the and with the audience attending the student presentation sessions.

In a scale of 1-4 (1 being Poor/Unsatisfactory and 4 being Excellent), students have been observed to have significantly gained on the different security modules and topics taught. The average student rating on their ability to incorporate security-related aspects in software development before taking both CSC 475 and CSC 450 has been observed to be 1.40; after taking CSC 475, but before CSC 450 has been observed to be 2.40; after taking both CSC 475 and CSC 450 has been found to be 3.55. This shows that students realized the importance of incorporating security in all phases of software lifecycle in an iterative manner. The above results are for the Fall 2010-Spring 2011 cycle.

**Dissemination:** We have developed a website for our project http://www.jsums.edu/cms/tues. All security related modules (along with project descriptions and question bank) developed on this grant are posted at this site. The materials for the TUES-affiliated courses (CSC 435 Computer Networks, CSC 438 Systems and Software Security and CSC 439 Advanced Information Security) are posted at this site for each semester. In addition, we have published a total of 15 articles (five peer-reviewed journal papers, three peer-reviewed conference papers, one peer-reviewed book chapter, six non peer-reviewed abstracts/presentations) featuring the educational and research work conducted through this grant.

During the 2012-13 academic year, we plan to contact instructors at other institutions to adopt our security modules into their software engineering courses and evaluate the perceived benefits in the knowledge base of the students.

**Impact:** The PI has created three new courses on security and incorporated into the undergraduate curriculum. The course proposals can be obtained at http://www.jsums.edu/cms/nmehanathan/html/courseProposal.html. The three courses are CSC 437 Computer Security, CSC 438 Systems and Software Security and CSC 439 Advanced Information Security. This way, the Computer Science Department will sustain the project-related activities after the funding period and will continue to offer the security courses. The grant has enabled the PI to gain more insights into security-related research and education and Software Security has now become one of the primary areas of research for the PI.

The PI has published a total of 15 articles (including 5 peer-reviewed journal papers, 3 peer-reviewed conference papers and 1 peer-reviewed book chapter) with the grant support. In addition, the PI has submitted a TUES-Type II grant on Software Safety (in collaboration with another TUES-Type I institution) to broaden the impacts of software security and safety in the undergraduate computer science curriculum. Last but not the least, the undergraduate students (especially juniors and seniors) taking the elective courses on security, the core courses that teach security modules (network security, database security) as well as the software engineering and senior capstone project courses are able to appreciate the importance of systems and software security and incorporating them into software development lifecycle.

**Challenges:** During the first year of the project, the PI (security expert) and Co-PI (regular software engineering instructor who is not a security expert) co-taught the CSC 450 Senior Project and CSC 475 Software Engineering courses to incorporate the security aspects. The Co-PI attended these sessions to gain insight into the security topics. However, students perceived the lectures and the quizzes/exams/lab projects given by two
different instructors for a single course, as a significant increase in their workload. Hence, starting from the 2011-12 academic year, the Co-PI, who is also the primary instructor of these two courses (Hyunju Kim), seamlessly integrated the security modules developed by the PI into her lecture modules on traditional software engineering topics and taught by herself all of the modules, including those focusing on security. The PI and Co-PI collaborate offline to infuse security into the lecture modules.

Even though we offered two new elective courses on security that can be taken by juniors and seniors, to increase exposure of security to all students in the curriculum, we infused a module on Network Security and another module on Database Security respectively into our senior-year Computer Networks course and junior-year Database Systems course (both are required courses).

**116**

**PI:** Kara Nance  
**Institution:** University of Alaska Fairbanks  
**Project Title:** Remote Access Virtualized Environments (RAVE): Piloting a National Infrastructure for Cybersecurity Education  
**Project Number:** 1023125  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** Our goals include demonstrating the scalability and replicability of the prototype remote access isolated virtual laboratory environment and to contribute to widespread adoption of this instructional technology.

**Methods & Strategies:** We are piloting a scalable, expandable infrastructure for national remote access isolated virtual laboratories for computer security education to help educate the next generation of cyberinfrastructure defenders.

**Evaluation Methods & Results:** We have a Ph.D. in instructional design who is evaluating the educational environment as his dissertation topic and measuring the effectiveness of it as an educational tool.

**Dissemination:** We conduct regional training targeting faculty to increase awareness of this national resource and to encourage use and creation of supporting materials.

**Impact:** This project has by far exceeded our intended audience. It has reached a national audience and was most recently used for the at-large collegiate cyber-defense competition (CCDC).

**Challenges:** The unexpected number of national RAVE sites that we have installed (eight so far, rather than the two originally proposed) has created an unintended administrative burden that we need to determine how to address.

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**117**

**PI:** Kai Qian  
**Institution:** Southern Polytechnic State University  
**Project Title:** Collaborative Research: Portable, Modular, Modern Technology Infused Courseware for Broader Embedded Systems Education  
**Project Number:** 0942097  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** Broaden Embedded Systems Education via Modern Technology Infused and modular designed Courseware with hands-on labs in a portable box.

**Methods & Strategies:** (1) The developed courseware is providing portable real labs with SDKs of microcontrollers and smart devices that is expandable and affordable. This removes the barrier of setting up high cost embedded systems labs; (2) The modular design gives instructors the flexibility to adopt the full course or integrate selected modules based on their specific needs.

**Evaluation Methods & Results:** Informal student interviews and survey forms.

Based on the collected 56 copies of post-survey: 81% of students (45) responded agree or strongly agree which shows a very positive feedback from students. We would like to conclude that PEARL is an good teaching and learning strategy for embedded system education which has much potential for enhancing student STEM learning.

**Dissemination:**  
Implemented the project in five different courses (eight class sessions)  
1. Presented the project in ACM SIGCSE, ASEE/IEEE FIE, ACM ITICSE, and other Conferences  
2. Offered a special PERAL summer session for minority students  
3. Disseminated in a dedicated project web site  
4. Authored a textbook

**Impact:** The student feedback from the class implementations was very positive.

Based on the collected 56 copies of post-survey: 81% of students(45) responded agree or strongly agree which shows very positive learning outcomes.

Most students had no experience of programming with microcontrollers and enjoyed what they learned with this new hands-on labware. They understood better the fundamental concepts of embedded systems. Also, students were excited with their creativity opportunity on the embedded projects with the portable kits.
Challenges: Infusing modern technology such as mobile embedded systems is a challenge for instructors.

118
PI: Xiao Qin
Institution: Auburn University
Project Title: QoSec: A Novel Middleware-Based Approach to Teaching Computer Security Courses
Project Number: 0837341
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We propose a novel middleware-based approach to teaching computer security courses by constructing course projects for computer security education.

Methods & Strategies: In this pilot project we develop QoSec, an extensible middleware framework for computer security course projects. The QoSec framework provides valuable learning materials that can enable undergraduate students to gain unique experience of building large-scale trustworthy computer systems.

Evaluation Methods & Results: During the course of this project, quantitative evaluations are made to measure the outcomes of the project by analyzing the following key metrics. (1) Number and demographics of students enrolling in the computer security courses. (2) Number of students successfully accomplishing course projects. (3) Ratio of minority and female students who enroll. (4) The number of undergraduate students, upon the completion of the course objects in QoSec, being interested in taking the advanced computer security course.

Dissemination: To broaden educational impacts of the pilot research, results produced from this project are disseminated through conference/journal publications and presentations at regional and national conferences.

Impact: Survey results show that students are more interested in computer security after completing our designed projects.

Challenges: A challenge is how to integrate a research project into an undergraduate course.

119
PI: Bina Ramamurthy
Institution: University at Buffalo
Project Title: A Comprehensive Framework for Timely Introduction of Emerging Data-Intensive Computing to STEM Audiences
Project Number: 0920335
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Develop curriculum from the experiences and results from enterprise-scale, strategic, application-development and service improvement projects, for use within CSE courses, to better prepare students for professional practice.

Methods & Strategies:
1. Used NSF-IUCRC program to house the industry partnership, source and deliver projects, serve as advisory board, source and develop faculty.

120
PI: Rajiv Ramnath
Institution: Ohio State University
Project Title: Curriculum for Accelerated Services Engineering
Project Number: 0837555
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The goals of the project are (I) to create an undergraduate program for learning, teaching, research and discovery in data-intensive computing and (ii) to improve preparedness of our workforce for the emerging data-intensive computing area.

Methods & Strategies: The strategies and approaches of the project are: (I) Design and implement curriculum for a course in the emerging area of data-intensive computing (ii) Design, implement and institutionalize a certificate program in data-intensive computing and (iii) evaluate the effectiveness of the program.

Evaluation Methods & Results: The evaluation methods includes: (I) preparation of a questionnaires (ii) get Internal Review Board approval for the evaluation processes, (iii) survey the students to fill the questionnaires, and (iv) get the data analyzed by an external evaluator.

Dissemination: The project details are available on a wiki page. The course material is available on course web pages. PI discussed and demonstrated the project details at several national and international forums.

Impact: The certificate program has been approved by NY state level board and has been institutionalized at University at Buffalo. Other faculty members teach courses for the certificate program. Many students are interested in enrolling in the certificate program.

Challenges: One of the major challenges is provisioning the resources for the hands-on lab for the courses in data-intensive computing certificate. Fortunately Amazon Elastic Cloud Computing (EC2) provides free cloud resources for education purposes.
2. Use a mix of regular, clinical and adjunct faculty with industry and academic credentials to deliver courses.
3. Structured the courses around business and technical methodological frameworks.
4. Used an ‘inverted classroom’ and active learning approach within the classroom.

Evaluation Methods & Results:
1. Formative assessments through examinations and term projects.
2. Summative assessments through rubrics, open-ended questions for pre- and post- course evaluations and in-depth interview-based retrospectives with student samples and instructors.

Dissemination: Internal dissemination (complete): 1.) Integration with CSE program; 2.) Faculty training process; and 3.) Industry workshops to IUCRC members.

External dissemination: Publications - 12 (FIE-9, TEE-1, COMPSAC-1, Other-1). Books - 2, Book chapters: 4, International workshop: 1

Impact:
- Students impacted: 1070
- Faculty developed: 5
- Industry organizations engaged: 12 (4 are active partners in curriculum assessment and development)
- Related projects completed: 35

Challenges: Student acceptance for: (a) inverted classroom approach. Addressed by refining on-line lectures and increase in use of active learning techniques; and (b) breadth of curriculum. Addressed by guest lectures that connected curriculum with industry practices, use of adjunct faculty

Methods & Strategies: We are continuing the development of the software JFLAP for experimenting with theoretical computer science concepts. We are developing an interactive textbook that integrates the software JFLAP for learning and experimenting with the concepts.

Evaluation Methods & Results: We plan to survey courses using our approach from several universities. The survey would be done near the end of the grant, once the materials have been developed.

Dissemination: Our software and interactive textbook will be available online on our website, www.jflap.org. In addition we plan to publish in computer science education conferences.

Impact: The software JFLAP is already used worldwide in over 160 countries. We anticipate that providing an online interactive textbook that shows how to integrate the software with the material will only increase the impact of this software.

Challenges: No unexpected challenges at this time.

120
PI: Jungwoo Ryu
Institution: The Pennsylvania State University
Project Title: An Immersive Security Education Environment (I-SEE) Using Second Life
Project Number: 0817376
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The overall goal and intended outcomes of this project are to apply virtual 3D world technologies to developing innovative, student-centered learning modules and teaching strategies to enhance the security expertise of students and faculty in Computer and Information Science and Engineering.

Methods & Strategies: We use OpenSim (http://opensimulator.org), a 3D virtual world environment as an ideal platform to accomplish the goals and objectives of our project. We designed and developed three new security learning modules using OpenSim. All modules were implemented using team-based discovery learning.

Evaluation Methods & Results: Formative evaluation has been conducted to obtain feedback to improve learning modules, faculty training programs, and refine measures related to student learning. Summative evaluation has also been conducted to assess the extent to which the I-SEE information security learning modules improve students’ motivation, self-efficacy in the ability to take actions against security attacks, and perceived learning outcomes. The assessment results show that students are more engaged and perform better compared to the control group not using the learning modules.
Dissemination: We completed one faculty summer workshop on I-SEE learning modules which resulted in adoption by other universities such as Rochester Institute of Technology (RIT) and Regent University. Other Penn State campuses are also adopting the I-SEE learning modules. More faculty workshops are planned.

Impact: The learning modules appear to be very effective as a recruiting tool. Students who are not familiar with the computer security concepts seem to have an easier time to get to know the field through simulated e-commerce security and computer network attack-defense experiences provided by the I-SEE learning modules. The positive feedback we received so far indicates that students using the I-SEE learning modules are more engaged and having fun while learning compared to those exposed to traditional, lecture-based introduction to computer security.

Challenges: Some of the unexpected challenges include the difficulty in recruiting qualified software, game, and 3D model developers and the ever-changing nature of 3D open source virtual world software used for our project with minimum technical support.

123

PI: Madeleine Schep
Institution: Columbia College
Project Title: Computer Science for the Liberal Arts: Reaching an Untapped Pool of Students
Project Number: 0836877
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes:
1. To introduce computer science to a markedly increased number of students,
2. To increase students' appreciation of computer science,
3. To change students' negative perceptions about the computing field, and
4. To increase enrollment in introductory Computer and Information Science courses

Methods & Strategies: We have developed a computer science course designed to meet the college math general education requirements. The math topics and skills are completely integrated into the CS topics. This course explores a variety of CS topics to increase students' appreciation of computer science and its relevance in today's society. It also increases students' problem-solving skills.

Evaluation Methods & Results: We administer a pre- and post-survey that measures the perception of computers/computing as a male domain, the confidence in using computer, the perceived usefulness of computers, computer/computing liking, computer/computing anxiety, and computer science studies preference. The results show no statistical differences in pre- and post-survey results for any of the six measures, but unexpected high result in the pre-surveys can easily explain this result. We also perform pre- and post- course interviews that have shown in general increase confidence and greater positive attitude towards computers. Before the final report (coming up soon) we will work with the registrar's office to establish the effect of the course in enrollment in introductory CIS courses.

Dissemination: We have presented our work at poster session at SIGCSE 2011 and distributed some course CDs. We have a project website at http://cccis.columbiasc.edu/mschep/ccl/.

Impact: Overall, the course is a surprise to my students who still think that computer science is Power Point and Excel. Most of them are challenged by it because there is more abstraction than they are used too, but enjoy it because it is varied and explains topics relevant to them. Our college has just approved a new General Education program that will be implemented in the fall. The course created in this project has been approved for a newly created Information and Technology requirement (only two courses meet the requirement so far and one is a specialized course) and for the Quantitative reasoning requirement which replaces the mathematics requirement. We expect an increased enrollment and therefore, to be able to impact more students.

Challenges: Because the course satisfies the mathematics requirement, we have had too many students with very weak math background and weak logical reasoning. They wanted to avoid taking a math course by taking this course. We provided additional support for these students. Since the CIS and the Math programs work closely together and are part of the same division, it was not difficult to make sure that the Math lab which provides tutoring services, had at least one tutor able to help students in the course.

124

PI: Murali Sitaraman
Institution: Clemson University
Project Title: Hands-On Collaborative Reasoning Across the Curriculum - Phase II
Project Number: 1022941
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To inculcate and amplify, and ultimately institutionalize analytical reasoning principles across the computing curriculum at a diverse set of institutions, so that students can establish and understand the connections between building high quality software and mathematical principles.

Methods & Strategies: We use incrementally adoptable course modules, collaborative reasoning techniques, and supporting
Goals: We support the paradigm through hands-on blackboard and tool-supported activities through a web-integrated software development and reasoning environment.

Evaluation Methods & Results: We have developed a Reasoning Concept Inventory (RCI) to document principles that need to be taught across the curriculum for developing high quality software. We have developed and used learning outcomes based on the RCI for assessment at Clemson and elsewhere. We have already collected data for several courses and are using the assessment to tune our educational methods and techniques. We have supported the data using pre/post attitudinal surveys.

Dissemination: To date we have conducted 1 ACM SIGCSE panel, 2 ACM SIGCSE Workshops, 2 tutorials at the ACM Southeast conference, 1 workshop at the ACM Midwest conference, and 1 dedicated workshop for invited participants, in addition to SIGCSE BoF sessions. We also have a large web presence.

Impact: At Clemson, descriptions of 2 required courses have been modified to include analytical reasoning principles of software correctness and the principles have been institutionalized. So far 5 different faculty members and 3 teaching assistants have taught the principles in various courses.

Challenges: It has become clear faculty attempting to integrate new principles in their curricula at diverse institutions need some support to facilitate such integration. It is also clear that the web-integrated environment is crucial for widespread adoption and developing is to be suitable for diverse audience requires much tuning and refinement.

125
Pi: Leen-Kiat Soh
Institution: University of Nebraska
Project Title: Integrated Computational and Creative Thinking (IC2Think)
Project Number: 1122956
Type: Phase 2/Type 2 - Expansion
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: Our long term vision is to incorporate computational thinking and creative thinking into undergraduate STEM courses to better prepare students to be flexible and resourceful problem solvers, interdisciplinary collaborators, and skilled practitioners of both logic and creativity.

Methods & Strategies: We design and develop a set of creative thinking exercises for in-situ activities (either in class or lab) with CS1 computational thinking alignment; deploy these learning objects and exercises as integrated modules in Renaissance Computing courses; and evaluate the impact of these courses on students.

Evaluation Methods & Results: Formative evaluation will examine project progress in meeting objectives and completing planned activities in relation to grant time lines. Course enrollments and student demographics will document participation against the target population. Summative evaluation will determine achievement of the project goals of (1) designing a set of IC2Think learning modules, (2) improving students’ knowledge and skills in computational and creative thinking, (3) improving students’ learning and motivation for STEM disciplines and (4) increasing the number of students in STEM.

Dissemination: We will submit papers to conferences, primarily computer science education conferences such as SIGCSE, FIE, and ITiCSE. We will also work in conjunction with our Renaissance Computing team and the on-going NSF CPATH, BPC, and TUES communities and secondary schools to share the lesson modules online.

Impact: The project is still in its early stages. Anticipated impacts are as follows. The IC2Think project will improve STEM education in STEM (and also non-STEM) disciplines. We will be able to promote computational thinking primarily as an enabling problem solving approach and creative thinking as an enriching problem solving approach. Research studies and results of our investigation and evaluation will give us valuable insights into the approach’s effectiveness and reported in academic venues. Products such as modules will be used and disseminated through Renaissance Computing, and various NSF communities.

Challenges: Student apathy in our current CS1-Engineering course. Only a subset of students have participated actively in the IC2Think lesson modules. We have discussed with the instructors and made several changes. To encourage student participation, we now have regular reminders, better articulation of the rationale behind the design, reduce the complexity of the lesson modules, and also announce a gift draw for groups that have completed their lesson modules.

126
Pi: Aaron Striegel
Institution: University of Notre Dame
Project Title: Curriculum and Laboratory Development Through 3-D Interfacing via the Nintendo Wiimote
Project Number: 1130148
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The goal of the project is to create a modular toolkit for teaching computational thinking that uses intuitive motion-based interfacing (Nintendo Wii, Microsoft Kinect). The intended outcome are ready to use
teaching modules for various computational concepts / fundamentals.

**Methods & Strategies:** The work has created several open source toolkits across several popular languages (MATLAB, Java, C#) and accompanying documentation distributed through a Wiki. Instructors can select various modules as appropriate for the particular concept they would like to teach or simply build their own module.

**Evaluation Methods & Results:** We have employed several sets of small scale class testing assessing the ease of use of the modules for design/evaluation of computational thinking. In addition, a high school summer class was used in tandem with a RET to evaluate a particular application of modules with regards to mathematics. Results pointed to quick learning curve for students (1-2 tries to fully grasp) and glowing reviews by students using the system.

**Dissemination:** Our dissemination activities include publications at Frontiers in Education, a poster at the NAE Frontiers of Engineering Education Symposium (the PI was a selected participant), and on-going Wiki distribution/source code availability. We will also continue to add material as we develop it related to our courses.

**Impact:** The initial exposure of students has been quite glowing, particularly noted for the outreach to summer students and its impact on female students for learning various math concepts (applied via a RET project). From an institutional perspective, the tools led to a side project adapting techniques for health care (stroke rehab) and the tools are used in a class for HCI. Additional adaptation is slated for the fall for the upcoming year in our freshmen engineering class.

**Challenges:** There were two unexpected challenges. First, there were issues with support and getting the device drivers to work across a variety of platforms, particularly 64 bit versus 32 bit Windows. The issue was further compounded by multiple versions of MATLAB. Second, our freshmen engineering saw a core shift due to a new Associate Dean which made getting the material to the students more challenging.

127

**PI:** Massood Towhidnejad

**Institution:** Embry-Riddle Aeronautical University

**Project Title:** A Curriculum Wide Software Development Case Study

**Project Number:** 0941768

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of the project is to introduce the importance of all activities and the corresponding artifacts associated with the software development life cycle, through the use of case studies based on a single realistic and semi complex example.

**Methods & Strategies:** We have decided to develop artifacts and case modules based on a single realistic problem called Digital Homes. The artifacts are based on a full development life cycle, starting with a customer need statement all the way through software maintenance. Project artifacts and case modules are presented as part of multiple computing courses.

**Evaluation Methods & Results:** There are multiple evaluations method used in this project, and they are conducted by different evaluators. First level evaluation is conducted by the different team members, where each member evaluated other members’ artifacts. Graduate students and other faculty at our department are invited to evaluate the material that best match their interest. Students presented materials to their class and encouraged to provide anonymous feedback and evaluation of the material. During the faculty workshop, which 22 faculty from across US participated, they were asked to evaluate some of the project artifacts. The faculty from other universities who are using these materials are asked to provide feedback and evaluation of the material.

**Dissemination:** We have delivered or plan to deliver the following workshops (CCSCNE 2011, FIE 2012). We have panel presentation at ASEE 2012. We have the following presentations, SIGCSE 2011 Poster, ASEE 2011 paper, CSEE&T 2011 paper, FiE 2011 paper, CCSCNE 2011 poster, IREPS 2012 paper. In addition we were invited to deliver a keynote speech at IREPS 2012.

**Impact:** Students in a number of classes from freshman all the way to graduate classes in software engineering and computer science degree have been exposed to the project artifacts. Overall, students reacted positively to the project artifacts, and they believe the project material make it easier to understand needs for the different software development life cycle artifacts and the importance of project activities through different life cycle phases. The faculty who have used these material provided positive feedback regarding the usefulness of these artifacts in their classes. This is also true about the faculty from other universities who have used these materials.

**Challenges:** The biggest challenge is to convince the faculty to use the material in their classes for the first time. Most believe by doing so, they need to change some of their teaching material and potentially be forced to remove some of the critical material from their classes in order to open space/time to incorporate these new material. Once the faculty get over the initial integration, then there is usually no further resistance to continue use of these material.
**128**

**PI:** Mary Sheila Tracy  
**Institution:** University of Illinois Springfield  
**Project Title:** Can Ethics Instruction Improve Students’ Technical Skills in Computer Science?  
**Project Number:** 1044207  
**Type:** Educational Material Development Full Development (EMD-FD)  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** We are testing the existence of an ethics effect. Do students in CS1 who are taught about professional ethics tend to do better on technical aspects of CS1? We will also develop ethics and CS1 teaching materials.

**Methods & Strategies:** All of our work is online. We are developing lectures, activities, and assessments.

**Evaluation Methods & Results:** Online assessments, including multiple choice, fill in the blanks, and essay questions. Our only results are preliminary, with a few students. However, these preliminary results are encouraging.

**Dissemination:** Members of the team have given several talks, including an NSF Showcase at the 2012 SIGCSE meeting. We intend to give talks, write papers, and maintain an extensive website. We will also be teaching a workshop for participating CS1 teachers.

**Impact:** On students: improved CS1 online materials, especially short modules on ethics. Fellow faculty: support for CS1 teaching, especially ethics. The discipline: information about the ethics effect in CS1.

**Challenges:** We found it difficult to isolate the ethics teaching into discrete modules; it is our habit to integrate this material throughout the semester. We have accomplished the isolation for the sake of the experiment.

**Methods & Strategies:** (1) designing a pre-assessment instrument measuring student knowledge of data mining; (2) adapting course materials that will enhance problem solving skills through reflection, critique, and exercises; (3) developing interactive and animated courseware; and (4) using a continuous evaluation process.

**Evaluation Methods & Results:** Pre- and post-evaluation of student knowledge of data mining and a survey to assess the interactive and animated course - called hypertextbook. Evaluation results have been quite encouraging: the hypertext book evaluations show that students appreciate the material and find it helpful in improving their understanding. The pre- and post- evaluations show significant increase in data mining knowledge. PIs also gave the Index of Learning Styles to the students and adjusted the course accordingly. Student retention has improved. Student evaluations improved significantly at UH Downtown where the traditional course had been offered in the past.

**Dissemination:** Three conference papers were presented. A website was created and the hypertextbook was made available along with other materials on the website. The PIs also gave an NSF showcase presentation at SIGCSE 2012. A journal article is being prepared.

**Impact:** Student evaluations of the course, the projects and the hypertextbook have been positive. Two students from the course were inspired to continue this project further. Fellow faculty have viewed the hypertextbook and given some feedback. We anticipate that the course design will be sustained in future offerings of the course beyond the life of the project.

**Challenges:** One challenge has been that the UH Downtown students are visual learners and the UH students are more traditional learners. So the course design had to be adjusted a little.

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**129**

**PI:** Rakesh Verma  
**Institution:** University of Houston  
**Project Title:** Collaborative Research: An Interactive Undergraduate Data Mining Course with Industrial-Strength Projects  
**Project Number:** 0737404  
**Type:** Phase 1-Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** This project involves the integration of the undergraduate data mining course with real-world applications directed by domain experts. The goals are to promote essential data mining skills, to apply data mining techniques to real-world applications, and to increase student retention in the course.

**Methods & Strategies:** The primary goal is to instill in undergraduate students a strong knowledge of software testing principles and techniques. The major outcome is a set of modules that are easy to understand and facilitate the teaching of software testing more efficiently and effectively.
Methods & Strategies: A pedagogical model emphasizing a many-to-many relationship between courses and modules such that educational materials can be selectively applied to any appropriate course in a minimally intrusive way is used to expose students to software testing at different levels of their undergraduate careers.

Evaluation Methods & Results: The evaluation is divided into three broad stages: effectiveness of the implementation, meeting goals and objectives, and assessment of the overall impact. The evaluation processes are made up of formative evaluation for continual improvement, and summative evaluation for meeting the program goals, impact on student learning outcomes, etc.

More than 800 undergraduates have benefited since the commencement of our project. It is very clear that students are able to use the techniques discussed in class to help them better test their programs.

Dissemination: Instructional materials, teaching strategies, lessons learned, feedback from students, instructors, and the industry advisory board, etc. are disseminated through media such as a project website, conference presentations, journal publications, annual workshops, etc.

Impact: I have worked very closely with instructors in Computer Science at both UT-Dallas and Collin Community College, not only serving as a guest lecturer in their classes but also walking them through the course materials to enable them to teach the modules independently. The 2nd part is especially important as well-qualified instructors are essential to provide good education. Our data indicates that participating students understand the importance of software testing and intend to use these techniques to help them improve the quality of their programming assignments.

Challenges: A few instructors were concerned that the introduction of software testing to their classes may have an adverse impact on the materials which they originally intended to cover. We have successfully resolved this problem by the adoption of a many-to-many and minimally intrusive teaching strategy, giving instructors flexibility to determine what is appropriate for their classes.

Two senior lecturers of our team retired in the second year of the project. Although this was not completely unexpected, it still required us to make appropriate adjustments. We have been working with their replacements very successfully since then and are able to provide lectures to cover the instructional materials to students in all selected courses without any interruption.

131
PI: Li Yang
Institution: University of Tennessee at Chattanooga
Project Title: Collaborative Project: Teaching Cryptography Through Hands-on Learning and Case Studies
Project Number: 0942581
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The project will enrich IA curriculum by hands-on labs and case studies on cryptography, which increase student skills and faculty expertise.

Methods & Strategies: The hands-on labs focus on understanding properties and vulnerability of various cryptography techniques. The case studies challenge students with real-world cases in emerging areas in a collaborative environment. Modules can be incorporated into IA courses.

Evaluation Methods & Results: We evaluate effectiveness of the hands-on labs and case studies by pre- and post- course survey. The outcome of faculty workshop is evaluated by survey as well. Faculty survey has showed satisfaction and usefulness of the workshop. Student survey collected from Computer Network Security Course (4620/5620) has demonstrated expected outcomes of the projects.

Dissemination: We disseminated our project results by presenting papers, posters in security and education conferences such as CISSE, SIGCSE. We have also disseminated our results through faculty summer workshop in July 2011. Two more workshops will be held in 2012 and 2013.

Impact: The implementation of this project has produced significant impact to students, faculty, and my institutions. Students taking an IA course with cryptography in fall 2011 have showed interests in IA and continue to take more IA courses in spring 2012. Three faculty in my department participating in the summer workshop in July 2011 are interested in both IA and pedagogical hands-on labs. The success of this CCLI funding has attracted more faculty on UTC campus into research of innovative education approaches, evidenced by the increased number of TUES proposal submission this year.

Challenges: The workshop organization work was more than expected, but PI and the team worked hard and had a successful year-1 workshop. The experiences gained will help them to prepare for year 2 and year 3 workshops.

132
PI: Feng Zhu
Institution: University of Alabama in Huntsville
Project Title: PSP: A Novel Framework to Teach Students Security and Privacy for Pervasive Computing Environments
Project Number: 1043945
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We develop a framework to teach security and privacy for pervasive computing environments at the application level (secure service discovery protocols), the wireless network level (Bluetooth & Wi-Fi security), and the node level (security for smartphones and sensors).

**Methods & Strategies:** Our framework helps students in understanding foundational principles and new technologies. We develop hands-on exercises based on real-world issues to secure emerging devices and lower & higher layer network protocols from users’, administrators’ and programmers’ perspectives.

**Evaluation Methods & Results:** We will use both quantitative and qualitative methods to collect and analyze data. We will measure the interests and attitude of the students. We will measure the efficiency of our project design: whether a project contains nonessential and time-consuming tasks; whether project supporting materials are sufficient and helpful; and whether a project is at the suitable challenging level. We plan to evaluate the framework in networking classes and security classes in two different colleges in our university and also in another two universities.

**Dissemination:** We create the PSP Tutor website by using Drupal. The CS department in the University of Alabama in Huntsville will run a web server to make our material available. The web site is built in a way that both the PIs and others who are interested in sharing their materials may contribute contents.

**Impact:** The project is still in its early stages (started Oct. 2011). Our anticipated impacts include students will (1) learn, access, and secure various computing devices with different types of OSs (e.g., smartphones, sensors, and Android), (2) explore lower and higher layers of networking technologies (e.g., Bluetooth and service discovery protocols), and (3) understand the big picture of the threats and mitigation approaches for pervasive computing. Our fellow faculty may use the material in their courses. The PIs’ departments and university may attract students with the new technologies.

**Challenges:** Students who work on the project sometimes may not perform as expected and need more training. The PI devotes more time on the project and has been helping the students.

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**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The project aims to address the disconnection between computing and personal finance education by developing a novel strategy to teach programming and financial literacy simultaneously using student-developed computer games.

**Methods & Strategies:** Infuse financial literacy topics into several computing courses and engage students in the development of mobile applications and computer games to increase their learning interest.

**Evaluation Methods & Results:** The project is evaluated using an integrated framework that includes Accountability, Effectiveness, Impact, Organization Context, Unanticipated Consequences, Sustainability and Dissemination.

**Dissemination:** We have been using conference presentation and summer camps for K-12 students to disseminate the results. We plan to share teaching materials broadly by contributing them to NSDL.

**Impact:** The project has impacted more than 200 students enrolled in courses that implement the teaching strategy. It will continue in the next two years to improve learning effectiveness of several hundred additional students.

**Challenges:** A major challenge is that financial literacy and game development alone are not sufficient to motivate students, partially due to course load students have. We plan to experiment with a competitive mechanism where teams that perform well can win a prize.

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**ENGINEERING**

**134**  
**PI:** Raymundo Arroyave  
**Institution:** Texas A&M  
**Project Title:** CCL: Scaling Up: Classroom-wide Student-led Undergraduate Research Experience for the Introductory Materials Science Course  
**Project Number:** 0942298  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The objective of the proposed project is to renew a sophomore-level introductory materials science course. Shifting the emphasis away from lecture to active student engagement, the PIs propose to implement student-centered and student-led, classroom-wide research experiences.
**Methods & Strategies:** We are using student-centered active learning pedagogies based on research experiences. The effect of these curricular innovations are assessed through the use of standard instruments measuring attitudes, understanding of the subject and development of scientific reasoning capabilities.

**Evaluation Methods & Results:** The assessments are carried out on two groups of students each year. These assessments are used to measure the effect that student-led project has on: Improvement conceptual understanding of content of a sophomore-level, introductory materials science course; Development of specific scientific reasoning skills through direct experience with the scientific process; Incensement of the interest of sophomore undergraduate students in science/engineering in general and materials science in particular.

**Dissemination:** We have published two articles and created a website outlining the project and showcasing some student-led projects.

**Impact:** All participating students (400 students so far) have had the opportunity to be involved in research. Some of them have joined research groups. The assessment tools to measure the impact of the research experiences on students' learning/attitudes can easily be adapted to other experiment-based class activities in other courses. Finally, and possibly more importantly, the hands-on experimental activities are likely to improve retention among underrepresented groups by improving their sense of belonging in the broader engineering/science communities.

**Challenges:** One of the unexpected challenges was the use of standard tests. In the first year of the project we found that some of the aspects of the curriculum innovation we were trying to evaluate were not easily measured using standard tests. We are thus developing customized assessment tools that we will eventually publish in the literature.

**135**
**PI:** Melody Baglione  
**Institution:** Cooper Union  
**Project Title:** Building Sustainability into Control Systems Courses  
**Project Number:** 1044830  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The project aims to improve student learning of control systems by (1) creating new learning experiences that leverage a new energy efficient, LEED-certified academic building and (2) developing hands-on process control laboratory scenarios and assignments that connect traditional classroom theory to a building control systems theme.

**Methods & Strategies:** We plan to expose students to real-world applications of control systems theory by creating system descriptions and an interactive website with diagrams and photos of actual building systems (e.g., chillers, boilers, heat exchangers, air-handling units). We plan to develop new experimental scenarios using bench top process control rigs and a configurable software interface from Feedback, Inc.

**Evaluation Methods & Results:** Our assessment plan consists of both direct and indirect measures. Students take building tours and are asked to describe the systems in a short writing assignment. The assignment is evaluated using a cognitive skills rubric based on Bloom's Taxonomy. We are also using customized pre- and post-SALG (Student Assessment of Learning Gains) surveys. The preliminary results reveal the teaching strategies are beneficial yet supplemental background material would likely further improve student learning. We are also considering using focus groups or interviews, observations of student behavior, and/or concept inventories to assess learning gains and affective outcomes.

**Dissemination:** We are working on two technical papers (with accepted conference abstracts) describing preliminary and advanced building simulation and control work. I am in contact with other colleges with sustainable building design programs and have shared draft teaching materials and given building tours to other internal and external faculty. We also plan to launch a website and host a symposium.

**Impact:** The project impacts student learning by providing opportunities to apply control systems concepts and acquire valuable professional skills. Preliminary survey results generally reveal students view building systems tours as an opportunity to appreciate the real-world applicability of classroom theory. However, student surveys echo the PI's observations and assessment results and indicate a need for more background information and relevant assignments, which is within the scope of planned future work. As a result of this work, other faculty in the department have participated in building system tours and become motivated to also start integrating aspects of our building into their undergraduate courses (e.g. fluids, thermo, heat transfer).

**Challenges:** The proposed work includes developing new experimental scenarios based on bench top process control rigs from Feedback, Inc. The project award was delayed from the proposed start date and during the delay the process controller for the configurable software became obsolete. The PI decided to wait for the release of a new controller to ensure the possibility of future software upgrades. The release of the software interface for the new controller has been delayed until Fall 2012. This delay (along with the PI expecting a new baby this May) will result in a request for an extension of this project.
**136**  
**PI:** Reid Bailey  
**Institution:** University of Virginia  
**Project Title:** Collaborative Research: Technology Leaders: A Program to Prepare Students for Designing Multiscale Agile Systems  
**Project Number:** 0817389  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The primary goal of our project is to adapt existing curricula to support a new interdisciplinary curriculum focused on educating students capable of engaging both a systems perspective and a component perspective in their engineering work. The second goal is to transport this curriculum to other institutions.

**Methods & Strategies:** Starting from a clear vision for the objectives for students in the program, the new curriculum was constructed to develop grounding in multiple disciplines concurrently with developing skills to integrate knowledge from across the disciplines. Existing courses provided the basis for disciplinary grounding while the new courses focused more on integration. Strategies to engage authentic work have focused on internships and hands-on classes. A learning community was developed to engage all years of the program and create a clear sense of belonging for the students.

**Evaluation Methods & Results:** An external evaluator has employed a variety of methods including surveys, observations, and interviews with both students and faculty for program evaluation. Graduate students have/are undertaking two significant studies on students in the program. The first study, completed in 2010, focused on student perceptions of interdisciplinary and used interviews, surveys, and focus groups. The second study, started in 2011, focuses on how students from this program are different than their peers not in the program and is centered on a videotaped design task completed by teams of students.

Results (from all of the above) include identification of challenges related to 2-year and 4-year schools working together and factors necessary for successful collaborations, development of a engineering-specific model for interdisciplinary understanding, and identification of significant gender differences regarding what leadership is and preferences for roles on teams.

**Dissemination:** We have published at multiple conferences and journals. In addition, we held a special session at FIE 2010 and a gathering of individuals interested in electrical/computer and systems engineering integration in curricula at the American Society for Engineering Education Annual Conference (ASEE) in 2011. This gathering led not only to a session on this topic at ASEE 2012 but also to the sharing and borrowing of ideas among participants.

**Impact:** This project has created a new program at the University of Virginia (UVa) called the Technology Leaders Program (TLP). Twelve students graduated in 2012 and we will be up to roughly 25 graduates/year in 2014. A new faculty member is being hired to support the TLP. In addition, the TLP now involves mechanical engineering in addition to the original trio of computer, electrical, and systems engineering. Additionally, a new class in systems engineering is being taught at Piedmont Virginia Community College (PVCC) and students at PVCC are engaged in the activities at UVa. Finally, the aforementioned dissemination activities at ASEE (gathering of interested people in 2011, special session in 2012), has made impacts beyond UVa and PVCC.

**Challenges:** First, the challenge of working with a 2-year school that was an hour away was huge. We were unable to find a way to completely resolve these issues so we brought a closer community college into the program. Secondly, the challenges of transporting a curriculum are daunting. The idea of transporting one lab, a specific activity, some online lectures, or even a whole course is challenging enough, but to find schools where an entire curriculum can be transported seems nearly impossible.

We have responded to this by working to identify the essence of the program that is transportable and focusing on those core principles when presenting the program to people from other schools. In addition, we are investing significantly in evaluating graduates from this program -- the evidence gained from these studies will be critical in convincing other schools that the curriculum is worth being transported.

**137**  
**PI:** James Becker  
**Institution:** Montana State University  
**Project Title:** Student-Centered Learning Strategies for A Face-to-Face and Online Circuits Course  
**Project Number:** 0941660  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The goals of the project include: fully engaging both live-taught, and online students in the study of electric circuits, improving student mastery of well-articulated course learning objectives and promoting the deep approach to learning, thus enhancing students' skills in "self-learning."

**Methods & Strategies:** A set of active learning modules have been developed that allow students to utilize the standard concepts and techniques explored in the study of electrical circuits, to the application of practical circuits. Inquiry-based laboratories and active learning strategies are used to guide students in their explorations.
**Evaluation Methods & Results:** Scores on standard exams and on essay-type exams designed to probe deeper learning are being used to determine the effectiveness of the strategy. Student surveys and classroom observations by an assessment expert are being used to measure student engagement. Initial evaluation suggests, on balance, enhanced engagement and improved performance on deeper learning outcomes are realized through the adopted approach.

**Dissemination:** A conference paper has been accepted for presentation at the 2012 ASEE conference. A full paper is planned for submission upon completion of the second evaluation cycle. The PI is seeking individuals at other institutions to adopt the developed materials.

**Impact:** There have been many positive comments from students regarding the materials developed as a part of this activity. The PI's department head continues to encourage the refinement of the materials with the expectation that the approach will be used in other courses within the department. The PI expects that students studying electric circuits using the developed materials will enter future classes with more effective learning strategies in addition to a deeper understanding of the basics of electrical circuit analysis.

**Challenges:** Additional class time was required to help students comprehend the somewhat challenging concepts. By eliminating a few of the more esoteric points of the activities, materials have been focused to allow students to understand the key considerations in a more timely fashion.

**138**
**PI:** Edward Berger  
**Institution:** University of Virginia  
**Project Title:** The Engineering Genome Project  
**Project Number:** 1123037  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The Engineering Genome provides both novice learners (students) and domain experts (faculty) with a detailed, explorable ontology of engineering knowledge, including CONNECTIONS and RELATIONSHIPS among seemingly disparate pieces of information and a library of multimedia examples.

**Methods & Strategies:** We are developing the ontology using OWL libraries and a user (web) interface in javascript. Students and faculty will interrogate v. 1.0 of the Genome to explore connections and relationships, and access multimedia learning materials categorized according to the ontology.

**Evaluation Methods & Results:** Evaluation includes several facets. First, we will perform usability studies on the software tool/user interface itself to assure that the tool is usable, efficient, and conforms to student expectations about an online experience. Second, we will conduct targeted studies that explore how students learn with the Genome, specifically: are conceptual understanding and higher-order thinking outcomes accelerated for students who use the Genome (and explore its embedded relationships) compared to those who do not.

**Dissemination:** We will disseminate the work through the usual channels (ASEE conferences, journal articles, etc.), as well as through the web portal to the Genome itself. The early-stage goal is to engage students in engineering mechanics at several Universities to use the Genome and provide feedback.

**Impact:** We expect that the Genome will impact novices and experts alike, although obviously in different ways. Novices will be able to more readily see and understand the subtle connections between disparate pieces of information because the Genome will explicitly reveal those relationships. Experts will be able to mine the Genome for complex and previously-unseen relationships—unseen even by the experts. Moreover, by integrating curriculum information (i.e., courses, learning outcomes) and mapping it onto the Genome, experts will have a compelling analysis tool for the curriculum and its outcomes.

**Challenges:** We are currently working through the basic implementation challenge of establishing the platform on which development will occur. The part of this that was unexpected is the depth of this challenge—it has proven to be more complex than we first envisioned (and we knew it would be difficult). The Genome itself grows quickly, as do the attribute sets and relationships among those pieces of data. So developing a robust tool that can handle all this information at scale has exceeded our expectations for how challenging it would be.

**139**
**PI:** Rajesh Bhaskaran  
**Institution:** Cornell University  
**Project Title:** Integrating Advanced Simulations into Engineering Curricula: Helping Students to Approach Simulation like Experts  
**Project Number:** 0942706  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The goal is to develop learning materials and strategies that help undergraduate students learn the ‘expert approach’ in simulation. The expected outcome is that students would be able to emulate the behavior of experts while using simulation tools.

**Methods & Strategies:** Industry-standard simulation tools have been integrated into 7 diverse courses in Mechanical and Aerospace Engineering at Cornell University using web-based learning modules. A unified approach that foregrounds important aspects of expert thinking is used across the courses and disciplines.
Evaluation Methods & Results: Student learning outcomes are being assessed through performance on homework assignments and clicker questions. Student attitudes are being assessed using in-class and online surveys. Initial evidence indicates that a majority of students in one particular course were able to progress from accepting simulation results provided to them at face value to critiquing the results through hand calculations. In a survey from the same course, 91% of students said that the simulation exercises helped them visualize analytical results.

Dissemination: A workshop on the integration of simulation technology into engineering education was held at Cornell University in July 2011. This workshop was attended by 100 people from academia and industry. The web-based modules are being accessed by about 65,000 people from 130 countries.

Impact: Industry-standard simulation tools have been integrated into 7 diverse courses in Mechanical and Aerospace Engineering at Cornell University. The courses impacted include lecture and lab-based courses in different disciplinary areas: solid mechanics, fluid mechanics, heat transfer and dynamics. These courses are taught by 7 different faculty members with different teaching styles. Faculty from four other institutions are either using our web-based modules or are considering adopting them.

Challenges: A major challenge is to continually update the web-based modules as new versions of simulation software -- ANSYS in this case -- are released. Updating written instructions is very time-consuming. This challenge is being overcome by using YouTube video snippets to teach steps in the software. The YouTube snippets are embedded within the web-based modules. The video snippets are less time consuming to produce with the latest screen capture software. An added benefit is that the current generation of students seem to prefer learning through video rather than written instructions.

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PI: Sean Brophy
Institution: Purdue University
Project Title: Graphical Representations to Assess System Performance (GRASP): Assessment for Engineering Education
Project Number: 0817486
Type: Phase 2/Type 2 - Expansion
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The desired outcomes are to develop technology students can use to construct diagrams to support reasoning with graphical tools. Research results will help define how undergraduate students reason with these tools and the kind of feedback they need to improve their analysis performance.

Methods & Strategies: Classroom activities to generate and reason with diagrams are used to document the variance in students' ability to generate graphical representations and how they use them to generate new knowledge. Think aloud protocols provide a more focused investigation of students thinking and reasoning related to the construction task and asking what if questions.

Evaluation Methods & Results: Research on students learning and development of formative assessment technology was done in parallel. Research on learning consisted of a series of two students to describe how they learned. Results of these studies informed the specifications of the technology to be developed. Prototypes of the technology will be used in two additional studies of student learning. These comparative studies will evaluate the role of feedback on student learning and how it could be improved.

Dissemination: This work is being disseminated through publications, a workshop and website sharing tools and results of the research. The initial studies of student learning will be published in conference and journal publication. A workshop was conducted at ASEE 2011 conference.

Impact: The results from initial studies have informed the design of a first year engineering course involving design (computational) modeling. A comparative study across time indicates the structure and the focus of the instruction supports students' ability to model systems to support their design. Further the results indicated a potentially appropriate learning progression to support students' ability to generate useful diagrams to support their design thinking. Ultimately the methods and problems developed on this project will be available on a public website for faculty to use in their courses.

Challenges: The rapid change of available technologies has impacted the options on delivering the technologies. Therefore, the decision to pursue a different technology for the prototype development postponed the research studies. Also, the distributed nature of collaboration and the transition of personnel impeded the development of the desired technology.

141
PI: Susan Burkett
Institution: The University of Alabama
Project Title: EURO: Enhancing Undergraduate Research Opportunities
Project Number: 1123096
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The overall goal is to prepare undergraduate students for research using three different delivery formats. The intended outcomes include increasing student awareness of research opportunities and preparing students to conduct research in a responsible professional manner.
Methods & Strategies: The three formats for delivering educational material include a semester long seminar, a one-week intensive ‘boot camp’, and a 2 1/2 day peer-led short course. We are also coordinating these teaching efforts between three institutions: Washington State University (WSU), the University of Alabama (UA), and the University of Central Florida (UCF).

Evaluation Methods & Results: We are using a pre-post test to determine the change in knowledge concerning research related topics, professional and ethical behavior, and career opportunities requiring graduate degrees. For each teaching format, a focus group will be convened and coordinated by assessment personnel at UCF. Our project began last fall and the three institutions are teaching the semester long seminar this semester. Our first focus groups will be held in the next two weeks. The post-test will also be given during final exam week at each institution.

Dissemination: This summer, our group will hold a workshop at the National CUR conference. The project team members will visit the host campus this summer when the one-week boot camp is held at WSU and the 2 1/2 day short course is held at UCF. Either ASEE or FIE conferences will be attended next year.

Impact: The project is still in its early stages. We anticipate increased interest in research opportunities. Our institutions already have a strong commitment to undergraduate research and this project helps to fuel that commitment. The University of Alabama has initiated a program called Emerging Scholars which uses the semester long seminar approach and is aimed at freshmen STEM students. It is very successful and the institution is struggling with issues related to increased enrollment. UCF has been working with a living learning community that has also been very successful, while WSU has a long standing program to pair students with mentors. Our project is really leveraging all of these activities.

Challenges: The biggest challenge has been in understanding what level of knowledge the students have about research related activities such as literature review, technical writing, ownership of published work, documenting results, etc. We all have varying levels of students in our courses with varying majors as well. Trying to reach all student levels and provide relevant examples for them has been difficult. One thing that has helped is the collaboration. Our team has bi-weekly conference calls to plan our activities and talk about ones we have conducted. Using everyone’s experience and advice has helped tremendously.

Critical Thinking (EFFECTs) Development and Implementation
Project Number: 1022971
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The three main goals/outcomes are i) developing training materials on how to use EFFECTs; ii) building a community of practice; and iii) creating a digital library of EFFECTs instructional packages that other instructors can access and use in the classroom.

Methods & Strategies: EFFECTs are based on a driving question set in a real, relatable context. Students prepare an initial solution using a decision worksheet. Active learning and reflection stimulate critical thinking about concepts that guide students to a final solution (e.g. design report with reflection).

Evaluation Methods & Results: Student performance is assessed using a Core Knowledge/Critical Thinking rubric developed in a prior Type 1 project. Pre- and post-test assessment instruments (e.g. concept inventories and the Scientific Reasoning Test) are used to evaluate the impact of EFFECTs on student learning. End-of-course surveys are conducted to determine student perception of EFFECTs. Acquired data are housed in the Online Assessment Tool developed for this project. Results suggest that EFFECTs have a measurable, positive impact on student learning and influence how students think in other courses.

Dissemination: A website has been established (http://sdi.cee.sc.edu/effect). Training materials and instructional packages are being posted. Papers continue to be published/presented at ASEE Conferences. One journal paper is under review at ASEE AEE and two other journal papers are in preparation.

Impact: During this project, ten faculty members at the University of South Carolina (USC) and Marshall University (MU) have developed and implemented at least one EFFECT (as of the spring 2012 term). This expansion has resulted in 16 new EFFECTs taught in 14 undergraduate and graduate courses at the two institutions. Approximately 500 students have been impacted, and a fraction of those students have experienced EFFECTs in multiple courses. It is expected that the number of faculty and students impacted will increase as a result of training workshops in 2012 and 2013.

Challenges: Although not unexpected, one of the main challenges has been with effective implementation in large classes. Appropriate active learning exercises must be selected; the classroom layout has a significant influence on their effectiveness. For example, a new EFFECT was recently implemented in Statics (~80 students), which is held in a theater-style classroom. Hands-on activities were conducted during recitation (~20 students) in classrooms with individual desks and open floor space; anecdotal data suggests that this approach was successful.

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Pi: Juan Caicedo
Institution: University of South Carolina
Project Title: Collaborative Research: Implementing and Assessing Strategies for Environments for Fostering Effective
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**PI:** Terri Camesano  
**Institution:** Worcester Polytechnic Institute  
**Project Title:** CCLI: Developing Grand Challenges Nanobiotechnology Laboratory Experience for Sophomores  
**Project Number:** 0941746  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The overall goal of the project was to give undergraduate students the opportunity to learn nanobiotechnology through active, problem-based laboratory experiences articulated in a Grand Challenge, an inquiry-based module that students address in collaborative teams.

**Methods & Strategies:** We are using the Grand Challenges approach to provide students with real-world problems and allow them to develop skills to work towards relevant solutions.

**Evaluation Methods & Results:** We used evaluation to monitor and document implementation, to assess students' knowledge, skills and attitudes, and to determine attainment of project goals and objectives. The formative evaluation design is a case study, using mixed methods. The summative component is a one group pre-post outcome. Data came from: student response to surveys at the beginning and at the end of the course; relevant questions on the institutional course evaluation; interviews. Items on surveys included Likert and Likert-type rating scales, nominal questions, and open-ended questions.

**Dissemination:** Our dissemination thus far has been based on conference proceedings. We are working on a journal publication, which will reach a broader audience. We are also working on a design for placing the videos the class created online.

**Impact:** Overall, the students rated the course highly, with 64.3% rating it as good and 14.3% rating it as excellent. 14.3% rated it as average, while 7.1% selected the rating, fair. Students wrote that they “gained lab experience” and knowledge in a growing field. Another student said that the course was a good introduction to subject good research and lab opportunity. During a 1:1 interview, one of the 4 randomly selected students stated that it was one of the better classes I’ve taken here, just because of all the labs and open-ended stuff and labs and research you get to do.

**Challenges:** Our challenges have been at the institutional level. It was difficult to introduce a new course for sophomores because the Chemical Engineering sequence and organic chemistry courses and laboratories already have many contact hours per week. We had to change the time of our course several times and be as flexible as possible about our schedule, so that students with conflicts could still participate.

144
**PI:** Andres Carrano  
**Institution:** Rochester Institute of Technology  
**Project Title:** Integration of Experiential Learning to Develop Problem Solving Skills in Deaf and Hard of Hearing STEM Students  
**Project Number:** 1141076  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The main goal of the project is to develop an effective approach to impart problem solving skills among deaf and hard of hearing students.

**Methods & Strategies:** We propose immersing students in a context-rich, industry-like environment where they will execute systematic problem solving. This will be accompanied by module development, adaptation and implementation.

**Evaluation Methods & Results:** We will conduct assessment on one control cohort and three intervention cohorts. The instrument is a rubric applied to several case studies developed for the project. Each cohort will have a pre-assessment, a post-assessment and two follow up assessments. The evaluation will be completed by an external center specialized on Deaf and Hard of Hearing outcome assessment.

**Dissemination:** Dissemination will be accomplished with the following: (1) a workshop for STEM educators, (2) conferences in deaf higher education, (3) Publications in journals of engineering education, (4) making resources available through the Deaf STEM community alliance (NSF HRD 1127955).

**Impact:** We anticipate institutionalization of the methods within the National Technical Institute for the Deaf (NTID) and within the problem solving based courses within engineering. We expect some of these approaches to be adopted by other DHH serving institutions.

**Challenges:** None yet

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**PI:** Grisselle Centeno  
**Institution:** University of South Florida  
**Project Title:** Case Studies Development as Constructivist Pedagogy for Teaching Work Analysis and Design  
**Project Number:** 0737021  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The goals of this project are to revamp the Work Analysis and Design (WAD) course through the development of case studies as a constructivist teaching/learning approach; and to extend principles of WAD as they apply to non-traditional manufacturing environments.
**Methods & Strategies:** The methods include case-based and constructivist teaching. Constructivist pedagogy stimulates students to use their own experiences to continue gaining knowledge rather than providing it through a predetermined method. Cases are being developed through frequent interactions with industrial partners residing mainly in the service sector.

**Evaluation Methods & Results:** To ensure that the project objectives are being achieved, a formative evaluation approached is utilized. After evaluating student performance on the cases distributed, an improvement in the learning of the principles of WAD and better preparation to undertake projects requiring problem-solving, analysis and reasoning skills was noticed. Based on the results of the surveys, students felt better equipped to tackle open-ended problems and to transfer higher-order thinking in an independent or collaborative manner. In addition, a significant enhancement in students' communication skills through case discussions and presentations was noticed.

**Dissemination:** The material has been shared with neighbor institutions for assessment and to test transferability and scalability. A tutorial has been organized to demonstrate effective techniques for development and implementation. The final product will be available online. Results have been and will be presented/published at IIE and ASEEE.

**Impact:** This project serves a pilot method to guide faculty in developing course material using proven efficient case-based instruction in collaboration with industrial partners. It builds upon research regarding how engineering students learn better, and the general body of knowledge of case-based and constructivist teaching. Moreover, it generates data to understand how real world cases enhance conceptual knowledge of fundamental IE theories and facilitate long-term retention. We expect these cases to be adopted by instructors searching for meaningful applications of WAD to environments neglected in textbooks and the general literature.

**Challenges:** It has been a challenge to get approval to access the facilities of some industrial collaborators. In addition, data release, material documentation and permission for student distribution have been time consuming delaying in several occasions the targeted schedule for case implementation and discussion. We have maintained opened communication channels with key industrial representatives and evidenced our commitment to proprietary protocols and confidentiality.

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**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The overarching goal is to develop and use virtual reality experiments that are designed to emulate the learning environment of undergraduate solid mechanics and thermo-fluids labs. Two virtual reality (VR) experiments are implemented and assessed for impact on student learning.

**Methods & Strategies:** Two physical experiments have been transformed into 3-D interactive and immersive VR experiments. Two immersion levels, namely 3-D TV and a CAVE (Cave Automatic Virtual Environment) have been assessed using human computer Interfaces (HCI) to provide students pre-lab experience.

**Evaluation Methods & Results:** Both quantitative (quiz) as well as qualitative (direct observation and student survey) assessment instruments were used. Quantitative analysis of assessment results, using 'control' and an 'experimental' groups showed that the 'CAVE VR' module resulted in a higher level of student learning when compared with the '3-D TV VR' module. The direct observation of both 'Experimental' and 'Control' groups clearly pointed to student learning gains for the 'experimental' group. Student survey showed students' positive disposition towards the introduced VR modules.

**Dissemination:** One paper has been accepted for the ASEE annual conference. Two institutions, a community college and a 4-year college partnering with ODU will implement the VR modules, and a 'Technology Enhanced Engineering Laboratory Instruction' workshop will be organized in fall 2012.

**Impact:** In the MAE 305 course (Thermo-fluids lab) 100 students, and in the MAE 225 course (Solid Mechanics Lab) 60 students have participated. Direct observation of students participating in experimental activities indicated that students using the pre-lab practice session with the VR modules were better prepared to undertake the physical experiment compared to the 'control' groups. Students at other community college and regional universities will also benefit from implementation of these modules, developed at ODU, during Fall 2012.

**Challenges:** Fortunately the project has proceeded smoothly so far without any unforeseen problems.

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**PI:** Sushil K. Chaturvedi
**Institution:** Old Dominion University
**Project Title:** Engineering Laboratory Instruction in Immersive Virtual Environment (ENLIVEN)
**Project Number:** 1043895
**Type:** Phase 1/Type 1 - Exploratory

147
**PI:** Xuemin Chen
**Institution:** Texas Southern University
**Project Title:** Collaborative Research: Developing Virtual and Remote Undergraduate Laboratory for Engineering Technology
**Project Number:** 0942778
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Creating Learning Materials and Teaching Strategies
Goals & Intended Outcomes: The goal of this project is to revamp the DSP experiments with virtual and remote functionalities for improving the learning of under-represented student population in Engineering Technology program. The intended outcomes are virtual and remote DSP experiments.

Methods & Strategies:
1. Developing a state of the art framework for developing and managing the virtual and remote experiments; and
2. Using the Web 2.0 technologies such as JavaScript, AJAX, jQuery, JSON and FLOT to develop the plug-in free remote DSP experiments.

Evaluation Methods & Results: The evaluation was based on the survey results. Total 29 valid survey forms had been collected from the Annual TSU-Unite/Jets Summer Pre-College Engineering program students on July 5. 65.5% students found the VR-Lab is very effective or effective. Only 6.9% students found the VR-Lab is not effective. 65.5% students found the VR-Lab is very friendly or friendly. 51.7% students replied strongly yes and yes for, “Does the virtual/remote experiment encourage you to pursue a career in Science Technology Engineering and Math (STEM) areas?”

Dissemination: With the partially support from this project, the research findings have been disseminated through faculty expertise workshop, conferences, book chapter, and Texas Southern University annual research week etc. We will submit papers to journals.

Impact: This project helped us to establish a state of the art Virtual and Remote Laboratory (VR-Lab) at TSU, improved the teaching facilities for undergraduate STEM education. The undergraduate students involved in this project have won several highly competitive awards for undergraduate research local and nationwide. One faculty submitted a proposal for applying TSU seed grant to develop remote experiments for Electronic course. The project PI received Distinguished Undergraduate Advising Award from college and Mentoring Undergraduate Research Award from the university.

Challenges: The challenge issue we encountered was the firewall. All the computers including servers at TSU network are behind the firewall. Only few ports are open such as ports 80 (http), 22 (ssl). An extra port was opened with help from the Office of IT at TSU. However, we found the reverse proxy server on Apache server does not work with the NI LabVIEW web server. The solution is to use the Pinhole, which is composed by Python. The newly developed plug-in free remote DSP experiments by using Web 2.0 technologies can resolve the firewall issue totally.

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PI: Karen Chou
Institution: Northwestern University
Project Title: Collaborative Research: An Interactive Steel Connection Teaching Tool - A Virtual Structure
Project Number: 1140468
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The outcome of the project is a web-based interactive version of the steel connection sculpture. The goal is to provide an effective learning opportunity and 24-7 access to students and educators in the United States and abroad.

Methods & Strategies: The virtual sculpture will show the close up view of each connection with description of how it may be used, potential failure modes, sample calculations, and field examples. 3-D finite element models are used to help students visualize the 3-D nature of the stresses in each connection when subjected to forces.

Evaluation Methods & Results: The quality and effectiveness of the proposed virtual sculpture will be assessed using formative and summative evaluations involving both students and faculty. The formative evaluation will consist of both student and faculty surveys about how the tools were used and the user-friendliness of the tools. The student learning outcomes will be assessed using the six levels of higher order thinking found in Bloom’s Revised Taxonomy with the lower order skills focus on remembering, knowing, and applying at a basic level, whereas the higher order skills focus on analyzing, evaluating and creating.

Dissemination: The virtual steel sculpture will be posted on the National Science Digital Library, National STEM Distributed Learning, and AISC WET (Web-Enhanced Teaching of Structural Steel) sites. And, it will be introduced at ASEE and iNEER conferences, and AISC educator seminars.

Impact: The virtual steel sculpture will help students better visualize how members could be connected. The tool is accessible to students and educators 24-7 globally. And, this tool would allow other educators and engineers to contribute to the database of design calculations and field examples. The results are better teachers, better-educated students, better-prepared engineers, and better communication with affiliated personnel. The tool also benefits other affiliated personnel such as architects, design technicians (drafting people), and construction managers.

Challenges: The project is in an early stage where no unexpected challenge was encountered.
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**PI:** Kenneth Connor  
**Institution:** Rensselaer Polytechnic Institute  
**Project Title:** Mobile Studio Environments to Enhance STEM Education  
**Project Number:** 0717832  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The Mobile Studio project is developing pedagogy and inexpensive hardware/software which when connected to a PC, provides functionality of laboratory equipment (scope, function generator, power supplies, DMM, etc.) typically associated with an instrumented studio classroom.

**Methods & Strategies:** The pedagogy is developed for the full range of circuits and electronics intensive courses in ECE and other engineering disciplines, throughout the collaborating institutions; it is also introduced in Physics, K-12, community colleges and other universities to establish its effectiveness.

**Evaluation Methods & Results:** Evaluation data sources for grant implementation included observations of classes (n=90); pre-course surveys on demographics, attitudes toward learning, and learning style preferences based on the Felder Index of Learning Styles (n=1,098); post-course surveys on perceptions of the Mobile Studio (n=827); post-course interviews of students and instructors (n=54); and students' achievement gains collected as part of final exam data (n=476).

**Dissemination:** The Mobile Studio was piloted at RPI in Circuits and transferred to Electronic Inst., Electronics and Physics II. Piloting and refinement at Rose Hulman and Howard, K-14 settings, training for science teachers and now other schools at all levels. Also conference presentations/workshops to relevant audiences.

**Impact:** Key findings:
1. Flexibility and adaptability of Mobile Studio to a diverse population of learners and instructional settings in higher ed, K-14, international undergrad engineering programs, and training for educators as well as variety of instructional uses including didactic, guided inquiry, active experimentation.
2. Use of the Mobile Studio resulted in an increase in knowledge retention; students performed better on items where it was used to supplement instruction; positive student perceptions of use in terms of self-reported learning, transfer to other classes and real world use.

**Challenges:** More instructor training required than anticipated (challenge transferring to other settings and sites). The opportunities for students to do hardware homework were limited by the lack of instructor experience in this area. At times it was difficult for a university to manage to produce enough boards. Students did not always see the relevance/usability in other courses, real world engineering and real world problem solving.

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**PI:** Eric Constans  
**Institution:** Rowan University  
**Project Title:** Making the Connection - Using a Long-Term Sustainable Design Project to Integrate the Mechanical Engineering Curriculum  
**Project Number:** 1044532  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** The goal of the project is to assess the effect of a long-term (3 year) design/build/test project on concept retention in mechanical engineering undergraduate students.

**Methods & Strategies:** The PIs have developed a large-scale design/build/test project (a bench-scale hybrid powertrain) that will be completed over the course of three years of the mechanical engineering curriculum. Integrating courses in this way is expected to increase subject matter retention among students.

**Evaluation Methods & Results:** Pre- and post-testing of students will be conducted in all courses affected by the project. The testing will consist of nationally-validated Concept Inventories in each subject, as well as ‘paper’ design exercises. The students are completing the first phase of the project this semester, so no comparative data are available yet.

**Dissemination:** Two conference presentations have been accepted to the ASEE National Convention in San Antonio in June of 2012. A wiki-type website will be developed in the upcoming year which will provide project descriptions, details and lesson plans for use by faculty nationwide.

**Impact:** The project is being developed by five of the eight faculty in the Mechanical Engineering program at Rowan, and the modules will be used in six core mechanical engineering courses. All undergraduate ME students at Rowan will participate in the project - approximately 40 students per course. In addition, two of the modules will be conducted and assessed at other institutions (Cal Poly San Luis Obispo and University of Dayton).

**Challenges:** So far, the project is proceeding as planned. There will undoubtedly be challenges that arise during implementation of the more difficult modules, but the PIs are constructing a ‘faculty prototype’ in order to anticipate the challenges that the students might face.
**Poster Abstracts**

**151**

**PI:** Shane Cotter  
**Institution:** Union College  
**Project Title:** CSI Union: Understanding Forensic and Biometric Technologies  
**Project Number:** 0837458  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:**  
Goal 1: to create an applied signal processing course for ECE majors that will allow students to develop their own biometric identification technology  
Goal 2: develop a course for non-engineering majors that will introduce them to basic signal processing methods and their application in biometric systems.

**Methods & Strategies:** Both courses are hands-on and a laboratory space has been developed to house laboratory sections for both courses and allow students access to biometric hardware and software for classwork and research projects. Evaluation of student work is largely based on group projects, teamwork, and presentations.

**Evaluation Methods & Results:** The Signal and Systems Concept Inventory has been used to evaluate students knowledge of signal processing before and after the course with the intention of showing how this applied course will enhance ECE students’ understanding of concepts. Questionnaires that address some of the objectives of each of the courses were designed to evaluate if these objectives are being met.

**Dissemination:** Conference papers at ICASSP and EUSIPCO as well as the IEEE DSP Workshop. Two ASEE papers have also been published. Future conference papers are also anticipated.

**Impact:** The development of the laboratory has created excitement about the area of biometrics - students have responded to this by completing senior projects in the area. The laboratory and course offerings emphasize the interaction between biology and electrical engineering and this has attracted some students to the study of electrical engineering. The upper level course is being offered to Bioengineering students. The lower level course attracts students from many different disciplines.

**Challenges:** The first fingerprint sensors used were not very user-friendly so testing was required to find better sensors.

**Project Number:** 0942594  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:**  
- Demonstrate feasibility of low-cost multidisciplinary take-home labs for undergraduate mechanical, civil, computer engineering students;  
- Improve learning outcomes for diverse student population; and  
- Form community of scholars collaborating on at-home labs

**Methods & Strategies:**  
- Develop family of low-cost lab kits using piezoelectric sensors/actuators  
  Develop PC-based software customized to labs-to-go experiments; Develop course modules using the kits for take-home labs;  
- Develop web-based support infrastructure for take-home labs.

**Evaluation Methods & Results:**  
- External evaluator focusing on project process and products;  
- Surveys gather feedback from students during the course for short-term outcome assessment;  
- Lab results and examinations test learning progress; and  
- End of course surveys and course evaluations assess long-term outcomes

**Dissemination:**  
- Presented paper on sensing experiments and interim results at Earth & Space 2012 Conference Engineering Education session  
- Developing web-page expansion including system details and course modules  
- Lab tours and experiment demonstrations

**Impact:** The Labs-to-Go kits have been used in one undergraduate class at UHCL and have been the basis for a senior design team which is enhancing the smart beam apparatus with strain gauge and accelerometers. The kits have also stimulated an MS research topic on vehicle health monitoring using embedded sensors. Through the outreach efforts, we expect to stimulate curiosity and enthusiasm of high school students.

**Challenges:** We are facing challenges in two areas. First, extension from sensing to actuation is placing high demands on the capabilities of the low cost data acquisition and control module. We are exploring alternatives to reduce delays while maintaining low cost. We are also finding that experiments using the pre-built monitoring and control software require much less teaching assistant support than those requiring students to build their own software. We are investigating improved teaching assistant support methods as well as development software alternatives.

**152**

**PI:** James Dabney  
**Institution:** University of Houston - Clear Lake  
**Project Title:** Collaborative Research: Develop Innovative Labs-to-Go Kits for Multidisciplinary Undergraduate Engineering and Technology Education

**2013 TUES PRINCIPAL INVESTIGATORS (PIs) CONFERENCE**

Conference Program A81
Poster Abstracts

153
PI: Denny Davis
Institution: Washington State University
Project Title: Appraisal System for Superior Engineering Education Evaluation-Instrument Sharing and Scholarship (ASSESS)
Project Number: 1065486
Type: Phase 2/Type 2 - Expansion
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: The overall goal of the project is to create, test, and communicate a web-based database of evaluation instrument information that builds evaluation capacity of the engineering education community by: (a) enabling educators to locate and properly use high quality evaluation instruments and (b) supporting development of outstanding evaluation instruments.

Methods & Strategies: (1) Developing a database and user interface that enable users to locate instruments; (2) Establishing an appraisal process that reviews superior evaluation instruments; (3) Documenting performance of the software system and appraisal process, and (4) Conducting adoption research.

Evaluation Methods & Results:
- Project consultants review ASSESS system, instrument selection, and instrument review process.
- Formal adoption research interviewing four different groups of potential users of ASSESS throughout the development process.
- Background software gathering ASSESS usage data: tallying ASSESS site visits, documenting time on the site, and recording features utilized.
- User ratings of experiences using the ASSESS software: rating instruments and user experience and leaving comments regarding ratings.

Dissemination: Used ASEE ERM listserv to inform the community about ASSESS and invite participation in user surveys and presentations and proceedings papers at FIE (2011), ASEE (2012), FIE (2012).

Impact: User survey results showed strong interest among engineering educators in the ASSESS database. The ERM listserv message attracted attention and produced emails suggesting instruments to include and other databases or dissemination hubs with whom to develop linkages.

Challenges: Finding a graduate student to develop the required software was unsuccessful, so funds were refocused on a contract with a local software developer to do this work.

154
PI: Norbert Delatte
Institution: Cleveland State University
Project Title: Implementation and Assessment of Failure Case Studies in the Engineering Curriculum
Project Number: 0919487
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Assess the use of case studies in different programs and in different university settings, using the assessment materials developed at Cleveland State University. Data will be collected and analyzed at Cleveland State University.

Methods & Strategies: Data are gathered through student surveys and student focus groups, using similar instruments at all universities for comparison.

Evaluation Methods & Results: Each of the partnering universities will collect data on the impact of using case studies. Since few subcontractors, if any, have enough women and minorities in engineering to be statistically significant, aggregating the data will make it possible to determine overall trends. Some data have already been gathered from some of the participating universities. So far, the results appear to be similar to those found in previous work at Cleveland State University. We have analyzed trends across multiple universities and will be presenting our findings at the American Society for Engineering Education meeting in summer 2012.

Dissemination: Case studies web site http://matdl.org/failurescases/Main_Page
Journal publications as well as presentations at ASEE annual meeting and one regional meeting.

Impact: Student responses to the case studies continue to be very positive, as documented by the student surveys and focus groups. Trends hold across a variety of courses in different types of universities. Hopefully this documentation will convince participating universities to institutionalize the use of case studies in the curriculum, and provide a sound foundation for expanding to other universities that have not to date been participating in the project.

Challenges: The main challenge has been getting approval from the University IRB, which seems to keep changing rules.

155
PI: William DeLuca
Institution: North Carolina State University
Project Title: GRIdc II: Green Research for Incorporating Data in the Classroom Phase 2
Project Number: 0920268
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The focus of the project was to develop a living laboratory that provides access to performance data from renewable energy systems located at the Solar House complex on the campus of NC State University. A STEM pipeline component of the program engages pre-college students in project-based engineering design of sustainable technologies.

Methods & Strategies: The project evolved over three stages. Installation and debugging of the data acquisition system was followed by development of data base and user interface systems to access real-time and legacy data. Development and pilot testing of instructional material has lead to national publication of six GRIDc units.

Evaluation Methods & Results: Two assessment instruments have been developed, one to measure students' metacognitive perception of their thinking and problem-solving processes and the other to measure students' knowledge of common concepts and facts pertaining to renewable energy technologies. There were significant gains in post-test renewable energy general knowledge scores. Results also show a significant gain in some aspects of metacognitive performance. Mixed results in metacognition performance has lead to the development of laboratory activities to supplement instruction.

Dissemination: Internet dissemination include two web sites that provide access to renewable energy data and curriculum resources. Cingage Learning will be publishing six iChapters that use the renewable energy data collected at the solar house. In addition, the project team has completed numerous presentations at state and national conferences and conducted workshops for high school and middle school teachers and students.

Impact: The project has been featured in news releases from the University, College of Education, College of Engineering and Friday Institute for Educational Innovation. The STEM pipeline developed as part of the Type 2 phase has 18 middle school and 12 high schools in an annual engineering design competitive event where students design a 1/10 scale plug-in electric vehicle and solar charging station. Progress Energy and US Navy has provided funds to expand this program and additional funds are being sought from the private sector. The project has been extending its impact through the 7-16 education continuum.

Challenges: Insuring reliability of the data acquisition system has been challenging. Techniques to use smart grid data acquisition systems are being explored in cooperation of the FREEDM center, a NSF smart grid research center and NC State University.

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156
Pi: Hazar Dib
Institution: Purdue University
Project Title: Collaborative Research: An Interactive Steel Connection Teaching Tool - A Virtual Structure
Project Number: 1140468
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goals are to develop an interactive 3D virtual steel structure to teach Steel Connections to Engineering students, and to assess the effectiveness of the tool in the education of undergraduate students.

Methods & Strategies: An immersive, interactive, 3D, web accessible learning environment is created for the purpose of teaching the steel connections for Engineering students.

Evaluation Methods & Results: A formative evaluation will be conducted to rate usability, quality of models and interactivity and overall usefulness of the tool. A summative evaluation with undergraduate students will be conducted to determine the learning outcomes of using the developed tool.

Dissemination: The results will be disseminated at the American Society of Engineering Education (ASEE), the International Network of Engineering Education Research (INEER), and AISC educator seminar.

Impact: The proposed virtual steel sculpture will help students better visualize how members could be connected. This interactive educational tool is accessible to students and educators 24-7 in the United States and abroad. The tool also benefits other affiliated personnel such as architects, design technicians (drafting people), and construction managers.

Challenges: The project just started. This section is not applicable.

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157
Pi: Jianyu Dong
Institution: California State Univ. Los Angeles
Project Title: Enhance Computer Network Curriculum Using Collaborative Project-based Learning
Project Number: 0941839
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The project goals are three folds: 1) Establish a cyber-infrastructure to enable remote learning which significantly improve the learning efficiency of students on a commuter campus; 2) Foster students’ hands-on design and implementation skills in networking field; 3) Improve
teaching and learning efficiency by integrating project-based and inquiry-based learning pedagogy.

**Methods & Strategies:** Our project extends the scope of Collaborative Project-based Learning by creating a sequence of scalable remote labs to enable the integration of project-based and inquiry-based based learning to existing computer networks courses. The remote lab sequence offers a rich variety of projects, e.g. small scope projects that can be incorporated into lectures, median scope projects that can be used to reinforce the students’ design skills, and large scope projects that can lead to independent study or senior design project. Similar to our previously proposed CPBL, the remote lab sequence will create a pipelined structure to enhance students’ design skills step-by-step, but it goes beyond the boundary of classroom by incorporating remote learning.

**Evaluation Methods & Results:** To measure the impact of the course revision on student learning outcomes and to ensure the smooth implementation of CPBL, comprehensive evaluation using both direct and indirect assessment instruments was conducted. The assessment tools include pre and post surveys, online project survey, focus group discussion and class observation. The assessment was collaboratively performed by the PIs and our external evaluator who is an expert from the College of Education. Overall assessment results are positive that indicates good potential to enhance the student learning outcomes and to increase student retention in this field.

Assessment also revealed unique challenges related to remote project-based learning. We will be happy to share our assessment results and the lessons learned through the year one implementation with other PIs.

**Dissemination:** We have published our project progress in ASEE annual conference in 2011. This year, we will publish and present our assessment results and project improvement in ASEE conference in June. In addition to publications, we established a website to share our project experience and disseminate all the developed course materials after they are tested in class. Currently, we are also planning to host workshops to disseminate our teaching strategies through the ‘Teaching Excellence Center’ on campus.

**Impact:** The revised courses have been implemented in Winter 2011, Spring 2011 and Winter 2012. About 100 students were directly impacted by the established cyber-infrastructure and the remote project sequence. In fact, more courses are using the cyber-infrastructure now to increase the computer access for our students, which significantly benefits a large number of students on a commuter campus.

Since the proposed curriculum revision involves both Electrical Engineering and Computer Science departments, the successful implementation of CPBL stimulates the faculty members in both departments to reconsider their teaching pedagogy. With our planned dissemination workshops on campus, we are expecting to help change the culture in college of ECST and help to transform the traditional engineering classroom to a more active and student-centered learning environment. The developed OPNET project materials will also benefit a broader education community of networking field.

**Challenges:** So far the biggest challenges we encountered are:

- How to further improve the cyber-learning infrastructure and overcome technical problems that may adversely affect the student project experience.
- How to improve the efficiency of remote collaborative project-based learning. How to schedule and adjust activities to be more efficient and effective given the tight course schedule in a 10-week quarter system.

The methods to deal with the above challenges are: 1) create clear polity for blade access and team management; 2) development of variety of online tools to help students learn OPNET modeler more effectively; 3) employment of better ways to provide timely feedback to students; and 4) continuous revision of CS470 and EE440 curriculum to better integrate in-class and after-class OPENT projects.

**158**

**PI:** Elliot Douglas

**Institution:** University of Florida

**Project Title:** Implementing Guided Inquiry in Diverse Institutions

**Project Number:** 1121111

**Type:** Phase 2/Type 2 - Expansion

**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** This project disseminates guided inquiry materials for the Introduction to Materials course at four diverse institutions, and examines how implementation varies based on the different institutional contexts.

**Methods & Strategies:** The co-PIs will attend workshops run by the POGIL Project and implement materials written by the PI. Formative and summative assessment will be conducted by an independent evaluation team.

**Evaluation Methods & Results:** The project has just begun and data is not yet available. Formative assessment will be qualitative and include two aspects: 1) goal-based evaluation of students’ and instructors’ goals focusing on the implementation goals, pedagogical goals, and student performance goals and 2) participant-oriented evaluation centering on implementation processes and community building. Summative assessment will be quantitative and include measures of student content knowledge, student satisfaction, and faculty implementation.
**Dissemination:** Dissemination will involve three main activities: 1) Publication of papers and presentations at conferences describing the work; 2) Workshops held at engineering education conferences; 3) Publication of the materials written by the PI, scheduled to occur in January 2013.

**Impact:** The direct impact will be on the faculty, who develop in their approaches to using novel pedagogies, and their students, who will experience enhanced learning through these pedagogies. More broadly, the work will examine how implementation depends on institutional context, and thus lay the groundwork for broader adoption in the future.

**Challenges:** The project has just begun and no unexpected challenges have occurred.

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**159**

**PI:** Raghu Echempati  
**Institution:** Kettering University  
**Project Title:** Collaborative Research: Transforming Web-based Courseware into a Full Statics Course with Digital Feedback and Assessment that Informs Interactive Classroom Activities  
**Project Number:** 0918255  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal is to improve students' understanding of Statics (Mechanics) concepts in an easy manner and assessed using advanced web-based tools. Paul Steif of Carnegie Mellon University is the lead PI on this collaborative grant.

**Methods & Strategies:** Use the Statics courseware developed by Paul Steif and Anna Dollar in freshmen statics course. Students go at a self-paced learning process to read the concepts and attempt online quizzes with immediate feedback. Assessment is done online to realize the weaknesses in students' understanding of the basic concepts presented.

**Evaluation Methods & Results:** Evaluation is done by assigning the reading material and assigning homework and quizzes for time-bound completion. After viewing the grade sheet, I discuss the strengths and weaknesses of the class as a whole and at an individual level to suggest corrective actions by asking them to solve the end of the chapter problems as homework. The data is presented in the form of table and charts for discussion and dissemination in educational conferences. The same Statics courseware is used for advanced courses such as Solid Mechanics, Machine Design and Finite element Analysis with similar evaluation tools.

**Dissemination:** As mentioned above, the results are analyzed thoroughly by the lead P.I. and published in educational journals such as Prism and J of Eng Education. At the P.I. level, I present the results at the ASEE conf annually. Plans are to continue the same until the project period ends in July 2013. I also plan to present seminar in our CETL center on the campus.

**Impact:** Students seem to like the static courseware and the quizzes to improve their performance in the statics course. A couple of fellow faculty also used these modules with some improvement in their students’ performance. Dissemination at the institute level (as CETL seminar) is yet to be given in Summer 2012. It is clearly documented by the lead P.I. that this courseware has impacted many schools at the national level. Efforts are also made to implement the course modules to the high school students at a local school.

**Challenges:** One of the unexpected challenges is that since the developed courseware does not follow the regular format and sequence of a standard textbook on Statics, some faculty tend not to use the modules directly while teaching their classes. Efforts to implement the use of course modules to the high school teachers are also difficult due to tight academic schedules and their commitments. I intend to give a seminar first to the institution faculty at Kettering (thru our CETL) and also to the local high school to show the potential and use of the developed modules in Physics and Statics.

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**160**

**PI:** Christine Ehlig-Economides  
**Institution:** Texas A&M University  
**Project Title:** Collaborative Research - Liver Energy  
**Project Number:** 1022932  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Goal to develop a continuously updated online textbook supporting core science courses about Energy Sustainability (ES) is expected to improve faculty collaboration in the short term and student learning in the long term.

**Methods & Strategies:** Methods include developing a collaborative that facilitates content development and use of features that are unique to an online textbook, a peer review mechanism, and a collective agreement regarding intellectual property and copyright.

**Evaluation Methods & Results:** Three outcomes that we envision worth studying are (1) the impact of an online textbook on student content learning, attitudes toward energy and toward the engineering field, and learning skills with respect to online resources, (2) the characteristics of faculty collaboration in developing the online resource, and (3) the adoption of the developed resource in teaching the ES courses. We have prepared 2 papers on the first 2 items. We also have an external project evaluator.
Dissemination: An Emergence of A Community-of-Practice: Five Engineering Faculty Co-Authoring An Electronic-and-Dynamic Textbook Material in Energy Sustainability’ for AERA; ‘Live Energy: An Initiative for Teaching Energy and Sustainability with Up-to-date and Dynamic Content’ for ASEE.

Impact: We expect the online textbook to elevate student awareness of the importance of energy and energy sustainability. We have collected student surveys at the start and end of courses using current more conventional textbooks to prepare a basis for comparison with survey results after the online textbook is introduced.

Challenges: One campus was unable to resolve IRB issues in time to collect the same data as the other 4 collaborating institutions were able to collect. Otherwise, we have successfully addressed challenges as they came up.

161
PI: Usama El Shamy
Institution: Southern Methodist University
Project Title: A Multi-Institutional Classroom Learning Environment for Geotechnical Engineering Education
Project Number: 1044585
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: to build/organize and test an online module for collaborations among students across different campuses; to assess the impact on student learning of working collaboratively with students at different campuses within a technology environment with regards to learning content and learning teamwork skills; and to test the viability of remote lab assignments taking advantage of NEES technology.

Methods & Strategies: It is proposed to develop an undergraduate course module to be implemented in courses offered at the three participating schools (SMU, RPI, and UNCC). The module assignment will be a model shallow foundation. The project activities will enable the students to design and conduct high quality experiments using the NEES geotechnical centrifuge facility at RPI. The students will access, interpret, evaluate and exchange relevant technical information via the Internet.

Evaluation Methods & Results: Qualitative methods will form the basis of the methodology, given the nature of the project, the evaluation questions and the number of participants. This is appropriate given the formative nature and the scope of the project (i.e., to develop and test a curriculum innovation as well as the associated assessment instruments). The methods involved will include: direct observations of students as they work in their teams, pre/post surveys focused on student attitudes towards learning, perceptions and opinions about the module, self-reports on the use of technology and ability to work in teams and attitudes towards the profession. Student learning will be assessed using embedded measures, i.e., the assignments associated with the module will be evaluated against a rubric (after the assignments have been graded) to determine changes in learning.

Dissemination:
- Development of add-on modules to be readily available for instructors’ inclusion within the framework for their course.
- Inviting colleagues to attend the Webcast of the experiment online by advertising the times of the experiments along with a description of the project.
- Experiment reports will be made available online for students use in class projects, and student competitions.
- Share the findings of the effort with colleagues from multiple universities with prime interest in civil engineering research and education.

Impact: The first installation of an educational module that for the first time integrates remote major research instrumentation into an undergraduate class was by all means a success. The students’ perception of the module was very positive. All students were impressed by the capabilities of the facility. Students agreed that it was very interesting to observe the stress distribution of the footing and loading it to failure in the live experiment. Students agreed that the experiment helped them better understand stress distribution and bearing capacity. Many students showed interest in seeing more experiments like this one for other applications in geotechnical engineering. The implemented course module aided filling a precarious gap in undergraduate geotechnical engineering education. Students lack the relationship between soil element testing and system design and performance. Testing a soil-foundation system helped the students identify the lab experiments needed to conduct the design of the system.

Challenges: The main challenge was the logistics associated with offering the module simultaneously at three schools. This challenge was dealt with by running the remote experiment multiple times to accommodate the different schedules at each school.

162
PI: Ning Fang
Institution: Utah State University
Project Title: Improving Students’ Problem-Solving in Engineering Dynamics Through Interactive Web-Based Simulation and Animation Modules
Project Number: 1122654
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goal is to develop and implement interactive web-based computer simulation and
animation (CSA) modules to improve students' problem-solving in engineering dynamics. The intended outcomes include improved student understanding and increased student interests in learning dynamics.

**Methods & Strategies:** Each CSA module integrates visualization with mathematical modeling of a representative real-world dynamics problem. Each CSA module has an interactive computer graphical user interface that allows students to vary inputs and see how the numerical numbers in mathematical equations change.

**Evaluation Methods & Results:** The evaluation plan includes: 1) Quantitative assessments of the overall effectiveness of all CSA modules. These will be completed by comparing students’ learning outcomes between the quasi-experimental groups and the control groups. 2) Quantitative assessments of the effectiveness of individual module. These will be completed by comparing students' academic performance in pre-post tests. 3) Statistical correlation analysis will be performed to determine the quantitative relationship between students’ learning style preferences and students’ learning outcomes with CSA.

**Dissemination:** The project results have been disseminated via presentations at an international conference and an ASEE Section Conference and via outreach activities to a high school. The project results will continue to be disseminated to ASEE annual conferences and will be submitted for journal publications.

**Impact:** The anticipated impacts include: 1) Students' physical and mathematical understanding of dynamics will be improved. 2) Students’ interest in learning dynamics and attitudes toward engineering will be increased. 3) The understanding of how CSA impacts the learning of students with diverse learning style preferences, genders, and ethnic/racial backgrounds will be improved. 4) Instructors at peer-institutions will adopt the CSA learning modules developed from this project.

**Challenges:** The primary challenge encountered was to educate and train graduate students for this project. Because of the unique requirements of computer simulation and animation modules, it took considerable time to train graduate students to develop those CSA modules. To prepare them for this project, all the graduate students recruited have been required to take a semester-long course on how to use Flash Adobe to design computer simulations and animations.

**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** The goal of our project is to develop an evidence-based institutional plan for motivating transformative change in faculty teaching practices. This will result in a more wide-spread translation of research to actual teaching behavior, and will benefit all students (especially women and other under-represented populations).

**Methods & Strategies:** The evidence we are using to develop our institutional change plan is based on a mixed-methods research design. It includes: a comprehensive review of and synthesis of the literature; quantitative analysis of ten years of demographic and academic data of engineering undergraduates at University of Michigan; student surveys and follow up interviews to identify faculty practices that promote and that hinder student success; classroom observations of engineering faculty; and focus groups with faculty to identify factors that might motivate them to change their practices.

**Evaluation Methods & Results:** To evaluate the impact of our efforts, we have collected data from a random sample of engineering faculty to establish the range of teaching practices currently used at University of Michigan. This data includes classroom observations (by trained consultants using a structured observation protocol) and faculty perceptions of both their approaches to teaching and their actual teaching behaviors (using published surveys). We will conduct future classroom observations and reassess faculty perceptions at multiple points, and we will compare these to our baseline assessments.

**Dissemination:** We have started sharing preliminary findings with several audiences at University of Michigan, including the 12 full time instructional consultants at our teaching center, several engineering administrators, and faculty interested in engineering education research. Although our research is local in context, our evidence-based approach to enabling institutional change can serve as a model for other institutions. Thus, broader dissemination of our work is a critical element of our efforts.

We have presented at the 2011 Research in Engineering Education Symposium and at the 2012 ASEE conference, we have submitted a proposal for a special issue of the *Journal of Engineering Education: The Complexities of Transforming Engineering Higher Education*, and we have drafted a manuscript for the International Journal of Engineering Education. As our project progresses, we will disseminate our work even more broadly.

**Impact:** Our project has the potential to transform the educational experience for all 5000 undergraduate and 2300 graduate students enrolled in our College of Engineering each year. Through our efforts, faculty will develop expertise in teaching practices that promote student learning, and the national community will understand more about issues in engineering education through our analyses of student and faculty data. Our work will also impact profession of faculty
development, as it will influence the way instructional consultants design their many department-specific programs, new faculty orientations, and preparing future faculty events.

**Challenges:** The main challenge we have encountered involves adhering to our planned timeline. As our research plan evolved, we found that each stage of the project could be viewed as its own rigorous project. Thus, keeping those projects brief became difficult. For instance, although we had initially planned only a small part of our project to visit classrooms of 10 strategically-recruited faculty, we decided a larger, random sample would provide us with a better baseline from which to measure change in faculty practices. As a result, we have notebooks filled with research notes from 26 classroom visits, consultants’ reflections on those visits, and pages of faculty perceptions of their teaching practices. This is a valuable component of our work, but it is one that has taken more time and expertise than we had planned.

**164**
**Pi:** James Goedert
**Institution:** University of Nebraska
**Project Title:** Virtual Interactive Construction Education (VICE-Bridge: A Project-Based Educational Paradigm using Cyberinfrastructure Tools)
**Project Number:** 1044627
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Goals and outcomes include: 1.) A serious game for a single span bridge; 2.) A high level of student engagement; 3.) Data collected and analyzed on levels of learning acquired through the use of the simulation; and 4.) Results and materials disseminated through NSDL, publications and workshops.

**Methods & Strategies:** Three construction investigators are partnering with two information science professors to develop a serious game. Players make decisions and calculation from real projects that are simulated in education modules. The game collects demographic information and performance measures.

**Evaluation Methods & Results:** The evaluation will be guided by the questions: 1.) the potential of the VICE for learning bridge construction management concepts and 2.) What if any technical, curricular, political and practical factors might inhibit usage in a post-secondary curriculum? The samples will be convenience sample using construction management and construction engineering students and 30-40 high school juniors. Internal quantitative evaluation data will be collected within the simulation and participants will complete the Student Assessment of Learning Gains.

**Dissemination:** The activities associated with this grant resulted in three conference proceedings and one journal publication. We expect to have publishable results within the next six months and plan to publish in two more journals and two additional conference proceedings and conduct a workshop.

**Impact:** The project is still in the early stages of development but we anticipate that this will be the preferred method for delivering construction education in the future. We are convinced that this should be pursued for the good of our students. The first beta test indicated a high level of interest and engagement. Students working on the project are continually finding new and better ways to enhance the simulations and the interface. There is a fine line for a manager to walk to encourage creativity and excitement and at the same time managing scope creep.

**Challenges:** One unexpected challenge was the complexity of communication across engineering and information science discipline that was exacerbated by the intimacy required to integrate a domain specific lesson plan into a serious game. Communication requires precise channels of communication between individuals unfamiliar with each other's vernacular. Much of this can be overcome with common management tools but the greatest gains come from working together. Another challenge was the absence of off the shelf animation tools that need to be developed.

**165**
**Pi:** Yi Guo
**Institution:** Stevens Institute of Technology
**Project Title:** Meeting the Educational Challenge in Mico/Nanorobotics for Biomedical Applications
**Project Number:** 0837584
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The project is addressing the education challenge through development, pilot testing, and dissemination of a set of modules in bio-nanorobotics that can be integrated into curricula in BME, electrical and computer engineering (ECE), and other disciplines.

**Methods & Strategies:** The main components include 1) the development of course materials on micro/nano-robot components and techniques, 2) the development of case studies and design examples on using micro- and/or nano-scale robots in biomedical environments and in biomedicine, and 3) the development of laboratory modules to teach robot programming and robotic functionalities (navigation and cooperation).

**Evaluation Methods & Results:** We have delivered the developed design example and laboratory module in one ECE course and two BME courses at Stevens Institute of Technology
in 2011 and 2012. We have collected lab reports and anonymous surveys to evaluate the results. The overall evaluation results are satisfactory. We will show the detail of the evaluation results in the conference.

**Dissemination:** We have delivered the developed design example and laboratory module in one ECE course and two BME courses at Stevens Institute of Technology in 2011 and 2012. We’re also packaging the teaching materials we developed for continuing dissemination. We have also published a few conference papers on the project, and an edited book and a journal paper are currently in preparation.

**Impact:** The course materials developed by this project added the breadth of the Autonomous Robots concentration in the ECE Department at Stevens. It provides stimulating and cross-fertilizing educational training that preserves disciplinary fundamentals in robotics and contributes to the related frontiers in biomedical engineering. The project also expanded the current curriculum of the BME program at Stevens and cutting-edge engineering technologies supporting biomedical applications were included.

**Challenges:** The main challenge we encountered is the simulation software we use to illustrate the idea. The robot simulator, Webots, is a commercial software, where a 30-day trial version with limited functionality can be free downloaded from the web. This limits what the students can do with the software and the time frame using the software.

**166**
**Pi:** Emad Habib  
**Institution:** University of Louisiana at Lafayette  
**Project Title:** Collaborative Research: Development of Adaptable Web Modules to Stimulate Active Learning in Hydrology using Data and Model Simulations  
**Project Number:** 1122898  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The overall goal of this project is to advance education in hydrology as a multi-faceted discipline. Project outcomes focus on developing hydrologic learning modules embedded within real-world ecosystems; adoption of the new learning modules in various course offerings; improved knowledge on design and effectiveness of case-based instruction delivered via web platforms in STEM education.

**Methods & Strategies:** The project will develop visual, case-based, data and simulation-driven learning experiences embedded within three US regional-scale natural systems (Coastal Louisiana, the Florida Everglades, and the Great Salt Lake Basin in Utah) to serve as educational Observatories delivered to instructors and students via a web server-based system.

**Evaluation Methods & Results:** Evaluation Plans: An improvement-focused evaluation model will be used to ensure that issues are identified and addressed early. A mixed-method research approach will guide data collection throughout the project duration. Qualitative data will be collected in both the formative and summative phases of program development and implementation to gain an understanding of why and how the proposed instructional solution works or fails to work and to inform improvement. Quantitative data on student learning in the summative phase allows evaluation of the project effectiveness in making a difference in student learning.

**Dissemination:** No dissemination for Phase II project has been done yet. However, in this first year of our Phase II project, and in preparation of our new developments, the pilot version of the project in Phase I was disseminated to an independent institution who adopted and adapted our HydroViz educational system for their own use with a local hydrologic system.

**Impact:** Anticipated Impacts:
1. Impact on Hydrologic Education as an area of recognized need.
2. Impact on diverse student populations (3 developing universities; and several other participating universities, and a high school).
3. Adaptation Impact through the design characteristics of the HydroViz system and the adaptation plan embedded during the different stages of the project.
4. Contribute to a paradigm shift: The project will contribute to a paradigm shift in adopting student-centered, context-rich, active learning strategies in undergraduate hydrology and STEM education.
5. The project will identify factors that are critical to the success of the project and develop them into a set of procedures and guidelines, which will guide similar future projects

**Challenges:** Not applicable yet

**167**
**Pi:** James Hanson  
**Institution:** California Polytechnic State University  
**Project Title:** Collaborative Research: Innovative Learning Styles and Universal Access for Geotechnical Engineering Education  
**Project Number:** 0817570  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The goals include enhancing geotechnical engineering education through development of learning-style specific teaching and learning activities. Project outcomes include universally accessible active learning modules
and pedagogical best-practices guidelines for implementation of learning activities.

Methods & Strategies: Incorporating learning-style specific assignments, novel communication technologies, synchronous interactions between partner universities and between universities and practitioners, multi-institutional teaming exercises, and student-produced learning modules.

Evaluation Methods & Results: Evaluation is being conducted from a variety of perspectives including overall impact on teaching and learning environments, pedagogical effectiveness of teaching and learning materials, evaluation of geotechnical aspects of materials, and quality of universal accessibility aspects of materials. Overall, the project has demonstrated success in engaging students in new ways for learning geotechnical engineering as well as developing professional skill sets of participating students.

Dissemination: Presented at ASEE Annual Conferences, ASCE Geo-Institute Conference, TUES/CCLI PI Conference, 4 international workshops, and 1 international conference. The PIs are working to develop journal publications and a project archive website.

Impact: The students that have participated in the project have elevated their learning experiences to include teaching other students, partnering on assignments with students from different universities, and interacting with professionals from the U.S. and abroad. Experiences with different learning styles have promoted students to work outside conventional learning environments. Other faculty have inquired as to recommendations for implementing these strategies in their courses. Numerous international universities have agreed to partner on this project.

Challenges: Scheduling between universities has been particularly challenging including both time zone issues and academic calendar issues. Balancing student workload with inclusion of new activities has been resolved by reducing workload on selected activities. Communication challenges for multi-institutional teams has been addressed by extending deadlines for teaming assignments. Teaching skills of video editing was necessary and challenging at the beginning of the project, however the need for such training has naturally subsided as incoming student skill sets have improved in this regard.

Project Number: 1044300
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The primary goal of this project is to create educational materials that systematically integrate biofuels technology into undergraduate chemical engineering curriculum. The outcome of this project is the creation of a set of comprehensive, flexible and apprehensible classroom and web modules that can be easily integrated into current chemical engineering curricula.

Methods & Strategies: Develop biofuels learning materials by simplifying and decomposing complex biofuels processes into a series of classroom and web learning modules, each module focuses on one aspect of fundamental chemical engineering principles and concepts.

Evaluation Methods & Results: Evaluation plans: Both formative and summative evaluation methods will be conducted by internal and external groups, and by an external professional evaluator. Student feedback will be collected periodically through the Assessment of their Learning Gains (SALG) system.

Dissemination: Completed: 2 posters at 2011 NOBCChE southeast/southwest regional meeting; Upcoming: Research Based Undergraduate Science Teaching Conference II; Continuing: Project website: BiofuelsAcademy.org; Planned: CACHE website; Oral presentations and posters at national conferences; Findings of student learning will be published on Journal of Chemical Engineering Education or PRISM Magazine published by ASEE.

Impact: Anticipated impacts: Because the developed learning modules are fully compatible with current chemical engineering curricula, they can be readily integrated into current curricula and have the potential to transform biofuels education nationwide.

The instructional strategies implemented in this project have been shown to have the potential to increase the number of students in STEM fields, especially of women and minority students.

Challenges: Unexpected challenges: Because all undergraduate students who participated in the project had little research experience, the progress had been slower than anticipated. Method of dealing: give more specific instructions and provide frequent guidance.
Project Number: 1044922  
Type: Phase 1/Type 1 - Exploratory  
Focus: Implementing Educational Innovations  

**Goals & Intended Outcomes:** The goal of this project is to contribute to the advancement of knowledge on effective online learning techniques related to engineering education. The intended outcome is the creation of a 'high-touch' learning model that provably enhances the success rate of the target population in STEM fields.

**Methods & Strategies:** Our methods involve the creation/insertion of early alert and other mechanisms for measuring student success within the on-line environment, and linking these to services, such as advising, coaching and tutoring, that should be deployed accordingly.

**Evaluation Methods & Results:** The evaluation plan consists of collecting student success data (completions, grades, etc.), as part of a course offering (both within and external to the study). Additional data will include capturing the alerts that were generated, every contact a student has with a service provided online, the perceived quality of that interaction, along with student demographic data and surveys.

**Dissemination:** This year's activities involved obtaining IRB approval from three different institutions within the state (Univ. of NM, Central NM CC, and Northern NM College), and the generation of a portion of the online curricula. In addition, survey instruments were developed and administered during the past month.

**Impact:** The project is in the early stages. The historical success rate for lower-division on-line engineering offering is very poor in the state of NM. This is contrast to upper-division and graduate offerings -- in these courses, students tended to succeed at a much higher rate. By creating a high-touch model, with more intimate feedback and monitoring of student progress, and more intrusive interventions. We anticipate an impact on student success for these lower division courses, as measured by an increase in the number of successful course completions, and an improvement in overall graduation rates.

**Challenges:** The two major challenges we have encountered are technical (administrative) in nature. First, it was extremely difficult and time consuming to go through the IRB approval process at three separate institutions. Second, the ability to enroll students from one institution, in a course at a different institution, has been a difficult and cumbersome process to manage. The first hurdle has been overcome.

In the second, we are working at the state level to alleviate the problem, with the hope of implementing a federated ID system that will allow students to enroll in courses across institutional boundaries.

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**PI:** Gretchen Hein  
**Institution:** Michigan Technological University  
**Project Title:** First-Year Innovation & Design in Engineering for Academic Success (IDEAS) Modules and Center  
**Project Number:** 0836861  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** To develop and institute a First-Year Engineering Learning Center. To develop and implement 3 design modules. To develop and assess critical and creative skills in engineering students.

**Methods & Strategies:** Three engineering design modules were developed for Wind Energy, Biomechanics and Aquaculture. Integrated the course topic with a design project focus into the first-year engineering pre-calculus track followed by the inclusion of the wind energy project into the calculus-ready track, summer youth programs (K-12 outreach).

**Evaluation Methods & Results:** Pre- and post-evaluations were completed on the following: Evaluated critical thinking using International Critical Thinking Basic Concepts and Understanding Test (www.criticalthinking.org). Assessed creativity using standard creativity scales and identified four unique factors for engineering creative self-efficacy. Developed and tested a communication rubric such that the inter-rater reliability between evaluators was statistically consistent. Post-project assessments were completed via student and faculty surveys.

**Dissemination:** We have published our activities at WEPAN, SWE, FIE and ASEE national conferences. We held a workshop for faculty to learn about the project. We have an IDEAS web site. We have adapted the projects for Summer Youth Programs (grades 8-12) and the Michigan Tech Mindtrekkers program.

**Impact:** The post-assessment data are still being completed. Therefore, the analysis has not been completed. Faculty and students using the modules have commented that they enjoy the real-world applications. Students commented in their surveys that they liked the integrated course topics. Faculty using the modules liked the project structure and implementation guidelines provided.

**Challenges:** The pilot test of the modules showed that students needed to construct their device and pre-test them because many of their designs failed when they were tested. In subsequent semesters, pre-testing to verify that the device works has been included in the design project activities, along with modifications of their design based on pre-testing performance results.
Poster Abstracts

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PI: Sandra Houston
Institution: Arizona State University
Project Title: Advancement of Unsaturated Soils Theory into the Undergraduate Civil Engineering Curriculum
Project Number: 1044012
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Goals for this project include the development, piloting, dissemination, and institutionalization of lecture and lab modules for educating undergraduate students in the principles of unsaturated soils theory and the application of these principles to problems of movement of structural foundation systems.

Methods & Strategies: Performance of a needs assessment (surveys and interviews) with specialists and undergraduate students. From feedback, prepare a detailed design document. During Phase 2 students and faculty at 6 universities will complete the same learning assessments and attitude measures.

Evaluation Methods & Results: Develop educational modules for introductory geotechnical courses. As part of a formative evaluation we will experiment with emerging methods and measures, including concept mapping, and will examine students’ conceptual changes. Six universities will pilot-test the educational modules. Evaluators from ASU’s Teaching and Learning Center staff will be involved. The design, development, and evaluation of materials will be focused on adaptability for ease of incorporation at other universities. Outcomes will be tied to established ABET outcomes (a-k) to facilitate adoption.

Dissemination: The educational materials and feedback from educators and learners will be uploaded to the National Science Digital Library and an open website for instructors. Web-based modules can be accessed from the project website, and faculty can adapt the suggested procedures to their specific course.

Impact: The project emphasis is on introduction of new educational materials to a change-resistant audience, and will serve as a model for updating engineering curriculum. The interdisciplinary team supports innovative research into education pedagogy. The introduction of unsaturated soil behavior into the undergraduate engineering curriculum is an important step for widespread adoption of these cost-saving methodologies in engineering practice. This project provides for recruitment and education of underrepresented STEM students.

Challenges: The project is just getting started. So far, our greatest challenge has been identification and recruitment of engineering and education students as research associates for the project. We had some delay associated with this step, but are now beginning the work of the research.

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PI: Steve Hsiung
Institution: Old Dominion University
Project Title: Dissemination of Microprocessor Courses through Classroom and Interactive Cyber-Enabled Technologies
Project Number: 1120000
Type: Phase 2/Type 2 - Expansion
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: 1) Enhancing the functionalities of an existing PIC training system and curriculum (developed through a Type 1 project) and supporting the training of others to use this instructional system. 2) Implementing new instructional strategies to enhance distance and face-to-face teaching and learning for this embedded technologies training system.

Methods & Strategies: Develop (a) audio and video demonstrations, (b) step-by-step guides to use hardware and software designs, and (c) delivering instruction through internet-based technologies.

Develop instructional materials to assist in the effective delivery of the microcontroller/microprocessor training for faculty at other colleges and universities.

Evaluation Methods & Results: Utilize the skills of workshop attendees, students, advisory committee members, and external evaluators to enhance the current PIC training system through improved hardware and software designs that meet the needs of ECE and EET curriculum requirements. Perform assessments such as surveys, pre- and post-tests, interviews, regular lecture and laboratory learning evaluations/tests, and teacher follow-up surveys on the effectiveness of the dissemination and transformation of the training system, instructional materials, distance learning tools, and student learning achievement.

Dissemination: Provide distance learning training to 120 faculty on the content and equipment to teach embedded technologies and student project applications. Collaborate with industry in updating of hardware and software development. Collaborate with interested faculty via distance training on course and project development. Provide course and teaching material for video streaming delivery.

Impact: The PIC Training System has been successfully implemented by project participating institutions (Old Dominion University, Tidewater Community College, Blue Ridge Community College, Wayne State University, and California State University-Fresno) and other early adopters (Bowling Green State University, Linn State, and Rock Valley College).

The training system received positive evaluations on cost and effectiveness in teaching embedded system design courses and effectiveness in labs and project designs. Further dissemination is planned through real-time on-line training of teachers. This
will broaden the benefits to other institution across the country in STEM related fields.

**Challenges:** The planned real-time distance training of the interested teachers is a major part of the project. The acceptance and changing learning habits will be an unexpected factor that affects the trainees' learning outcomes. With the assistance of the common hardware and software platform/trainer, designed course curriculum, step by step guides, audio and video training media, and various distance training tools, it is hoped that this will bridge the gap and reduce the teacher’s learning anxieties.

**173**

**PI:** Fei Hu  
**Institution:** University of Alabama  
**Project Title:** A Building-Block Approach to Tele-healthcare Engineering Education  
**Project Number:** 0941020  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal is to conduct the pioneering development of tele-healthcare educational materials based on our long-term research in this field. We will shape our research results into undergraduate labs/course materials based on a building-block development style.

**Methods & Strategies:** We have used the following two innovative development approaches: (1) Building-block development style, and (2) Multi-Dimensional Learning. We propose to use 4-dimensional pedagogy to develop and teach tele-healthcare engineering knowledge.

**Evaluation Methods & Results:** We have evaluated students' work in the following 4 aspects: 1) Development Efficiency that focuses on the appropriateness of the materials, (2) Breadth that indicates the collective coverage of the proposed materials, (3) Depth that measures the suitability to different levels of students, and (4) Student Learning Effectiveness that assesses student learning outcomes from each assignment.

**Dissemination:** We have been to ASEE 2011 to present our results. We have also broadcasted our development methodology to a medical school - UAB. We plan to go to this NSF meeting and other educational conferences.

**Impact:** We have offered a tele-healthcare seminar course for our students this Spring 2012. Students have used Physionet medical signal database to practice signal processing methods. Next-step, we will contact other biomedical engineering faculty on our outcomes.

**Challenges:** Before offering a 15-week semester course on tele-healthcare engineering, we have to overcome the challenge of letting students know its significance. Otherwise, we may not have many students registered for this course. The second challenge is to closely work with some medical doctors to make our teaching materials more clinical-like.

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**PI:** Jane Hunter  
**Institution:** The University of Arizona  
**Project Title:** Transforming the Undergraduate Engineering Experience: Using Cyberinfrastructure Tools to Introduce the Grand Challenges for Engineering  
**Project Number:** 1044480  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** To increase the commitment of freshman engineering students to the pursuit of engineering as an academic major and a profession; and increase the number of women and underrepresented minorities matriculating into engineering by giving freshmen and prospective engineering students an opportunity to choose from a selection of important and relevant topics to explore independently for a four-week period in the engineering foundation course.

**Methods & Strategies:** Web-based lines of study that use active-learning strategies have been developed by UA engineering faculty with expertise in selected topical areas. The five Elective Units were modeled after a pilot Unit that was previously developed and successfully implemented in the Introduction to Engineering course. The selection of topics for the Units was based on a survey that was conducted to identify which Grand Challenges interest our freshmen engineering students most. 3-4 minute vignettes were created for each Unit to inspire the students and to help them during the Unit selection process.

**Evaluation Methods & Results:** Both formative and summative evaluations of the newly developed Elective Units are underway. Initially, two undergraduate students were hired to evaluate the materials and provide immediate feedback to faculty members as the material was developed. Based on the feedback, the materials were refined. Next, eighteen students enrolled in a 1-credit elective course that was offered specifically for students who wished to evaluate the beta versions of the Units.

Multiple surveys and focus groups were conducted. Preliminary results indicated that the students found the material interesting and liked the opportunity to complete the activities in an online environment. Some elements of the Units were modified based on the feedback provided. Finally, the Units were launched in two sections of the Introduction to Engineering course with a total of 96 students enrolled (currently underway).

in addition to results of surveys and focus groups, assessment of student performance on graded assignments and analysis of the
amount of time students spent on the activities will be used to evaluate and update the Units.

**Dissemination:** The Units will be launched in eleven sections of Introduction to Engineering. All eleven of the College of Engineering faculty members teaching the sections will be educated on the Units by the original developers and will be responsible for supporting one or more of the Units. In addition, the Units will be adapted for a network of approximately 25 high schools that offer the Introduction to Engineering course. The high school teachers will be educated on the Units during a summer workshop.

**Impact:** The Elective Units provide an opportunity for students to explore topics that they find particularly interesting which should increase their commitment to engineering. The Units portray engineering as a helping profession which will enhance the perception of engineering, particularly for women. Active learning strategies, which have been incorporated throughout the Units, are known to improve student engagement and learning. A wide variety of online activities provide the opportunity to meet the needs of different types of learners. All of the faculty members and supporting graduate students that created the Units developed many new skills with respect to online learning. They also gained a new appreciation for the effectiveness of online learning when materials are developed appropriately. Faculty members who teach the Introduction to Engineering sections will become versed in topical areas that interest students but fall outside their areas of expertise and will extend their skills for creating, delivering and supporting online content in their courses.

**Challenges:** The grant was awarded later than originally anticipated so it was necessary to modify the schedule while working within the constraints of the academic calendar. The creative solution to this problem was to offer a 1-credit course for students who were interested in evaluating the beta versions of the Units. In this strategy, we used a design-build approach. As indicated, the Units are four weeks in duration. Students in the 1-credit class began working on Weeks 1 and 2 as the Unit developers continued to create Weeks 3 and 4. As soon as the student surveys and focus groups were completed for Weeks 1 and 2, the materials for Weeks 3 and 4 were delivered. In the meantime, the Unit developers made modifications to Weeks 1 and 2 based on the feedback from the “beta testers” to prepare for the rollout in the two sections of Introduction to Engineering later in the semester. Of course, this strategy was risky, but we were successful due to the dedication of the project team members.

**Project Number:** 0942366  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Our goal is to develop a series of integrated, progressively challenging, and interdependent curricular materials and activities that will improve the ability of Civil Engineering students to analyze engineering problems in multiple contexts using a GIS platform.

**Methods & Strategies:** The curriculum is collaboratively designed by the project team to integrate a GIS-enabled design approach using a sequenced and scaffolded structure to ensure a clear path for student skills progression in terms of technical competency, data analysis, multiple-context evaluation, and problem solving.

**Evaluation Methods & Results:** The evaluation plan consists of a series of evaluation questions addressed through a mixed-methods approach that includes course intro/exit surveys, skill competency assessments, student and faculty focus groups, student performance analysis (based upon project/course grades and GPA) and analysis of retention data. Data for a baseline cohort (Y0) will be compared to project student cohorts (Y1-Y3) for all analysis. Analysis of Y1 data indicate marked changes occurred in knowledge about GIS and promising retention of knowledge over time. It is too early to evaluate overall project impact.

**Dissemination:** The project team has prepared a paper that was accepted for presentation and publication at the 2012 American Society for Engineering Education Annual Conference and Exposition. In addition, modified project curriculum will be introduced in K-12 engineering outreach programs in June 2012.

**Impact:** We anticipate that students will demonstrate fluency in targeted GIS skills and an increased ability to analyze engineering problems in multiple contexts through the impact of this project. In addition to these expected, course-related cognitive outcomes, this project is expected to improve student attitudes concerning their course-based learning experiences by actively engaging them in visual-based learning processes. Finally, it is expected that changes in the project scope will lead to greater potential for transferability.

**Challenges:** While GIS and the ability to visualize Civil Engineering problems are of interest, the learning curve for the software is not nearly as steep as the faculty team originally expected. Students catch on quickly, and projects that were initially thought by faculty to be challenging in terms of the GIS applications have proven to be easy for students to master. Thus, changes are currently underway to increase the pace of the GIS skills introduced in each course and complexity of course projects to maintain student interest.
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PI: Timothy Jacobs  
Institution: Texas A&M University  
Project Title: TUES: Comprehensive Course Redesign: Thermodynamics for Next Generation Engineers  
Project Number: 1044875  
Type: Phase 1/Type 1 - Exploratory  
Focus: Implementing Educational Innovations  

Goals & Intended Outcomes: The goals of the project are to use challenge-based learning activities in a comprehensive redesign of the first thermodynamics course (FTC). Challenge-based activities will be carefully crafted to support students as they develop deep conceptualizations of entropy and available energy by seamlessly coupling micro and classical scales of thermodynamics so that they are equipped to design and develop tomorrow’s state-of-the-art energy technologies.

Methods & Strategies: Each challenge-based learning module will both integrate several thermodynamic concepts and foster independent and group research and problem solving among students. Further, most learning modules are oriented around comparisons of energy conversion technologies and will support students as they explore theoretical analyses and practical applications of these technologies. Texas A&M’s Mechanical Engineering Department will offer one section of the transformed course starting in Fall 2012 and running for the next three semesters.

Evaluation Methods & Results: Student learning in this transformed course will be evaluated in several ways, including comparison with traditional students in a second thermodynamics course. Materials for teaching the transformed course will be reviewed by an external advisory board composed of members from industry and academia.

Baseline data was collected in Fall 2011, where students taught with the conventional course were evaluated with quizzes at the start of each lecture. Further, a concept inventory was administered. Finally, a ‘lecture preference’ quiz was administered to assess the students’ ideas of their preferred methods of learning.

Dissemination: The project is still in its early phases, thus there have been no formal dissemination activities just yet. We are nearing the completion of our draft report summarizing the Fall 2011 Baseline data, which provides a quantified picture of the students’ current knowledge of thermodynamics.

Impact: In addition to better preparing next generation engineers with improved understanding of thermodynamics and energy related issues, the comprehensive course redesign offers the following impacts:

1. It will influence many engineering students across several disciplines (e.g., mechanical, petroleum, civil, and nuclear engineering).

2. Use of challenge-based learning modules in the course redesign, which emphasize problem/challenge-based approaches to conveying concepts, will improve student learning, success, and retention, including among underrepresented students.

3. Multiple dissemination mechanisms including an advisory board with members from industry and academia, development of a project website, journal article submissions, conference presentations, and active engagement with ME department heads will ensure broad applicability of the course redesign while also supporting other institutions striving to improve undergraduate thermodynamic course development.

Challenges: Project is still too young to have encountered challenges.

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PI: Kauser Jahan  
Institution: Rowan University  
Project Title: Hands on an Aquarium  
Project Number: 0737277  
Type: Educational Material Development Proof-of-Concept (EMD-POC)  
Focus: Creating Learning Materials and Teaching Strategies  

Goals & Intended Outcomes: The goals of the project were to ensure the highest quality SMET education. This project aims to improve undergraduate courses, curricula and laboratories by developing exciting hands-on, multidisciplinary, collaborative experiments; to increase participation of underrepresented minorities and persons with disabilities, and to ensure a high level of student retention in SMET areas; and to develop multidisciplinary curricula.

Methods & Strategies: A freshman course using an aquarium was developed to teach engineering principles. The activities developed were easily adaptable for K-12 educators. A living system generated more excitement than traditional engineering products in the learning process.

Evaluation Methods & Results: Paper course surveys and meetings with focus groups were used for evaluating and assessing the impact of the project. A class that did not use a living system for learning engineering principles was used as the control for comparison.

Dissemination: Dissemination has included presentations, paper publications in national and international conferences. A book chapter has also been published. An interactive web site is also available for rapid easy access for students and educators.

Impact: Faculty across disciplines were able to work together on developing innovative curricula using a living system.
Project generated major interest among freshman and many wanted to enroll in the course. The course was attractive to the female students.

**Challenges:** It was difficult to work with the county college as they had changes to their aquaculture program that was not anticipated during the proposal submission time.

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**PI:** David Kazmer  
**Institution:** University of Massachusetts Lowell  
**Project Title:** Collaborative Research: Engineering Faculty Engagement in Learning Through Service (EFELTS)  
**Project Number:** 1022738  
**Type:** National Dissemination (ND)  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:**
1. Disseminate service-learning pedagogy into more engineering curricula;  
2. Survey and assess the role of service-learning with respect to faculty motivation & development.

**Methods & Strategies:**
1. Faculty development workshops;  
2. Socials/meetings with professional conferences;  
3. Follow-up & support via social networks.

**Evaluation Methods & Results:** Thought leaders in the field have gathered and provided oral interviews which are being transcribed for qualitative analysis. Faculty development workshops are just now rolling out with launch of registrations as of March 1, 2012. There will be pre & post assessments of faculty followed by longitudinal surveys of faculty after course implementations.

**Dissemination:** Contributing to the American Society of Engineering Education (ASEE) Constituent Committee Community Engagement in Engineering Education; journal publications planned; website for archival of course templates and other assessment results.

**Impact:** Anticipated impacts are: 1) increased number of faculty practicing service-learning, 2) increased number of tenured faculty practicing service-learning, 3) increased publication rates related to service-learning by participants.

**Challenges:** No unexpected challenges, but meeting the expected challenges: 1) conflicts with traditional research, 2) lack of administrative support, etc.

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**PI:** Mohammad Khavanin  
**Institution:** University of North Dakota  
**Project Title:** CALCULATE: Curricular Advances to Learn Calculus and Understand the Lessons that are Appropriate to Engineering  
**Project Number:** 0942270  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The objective of this project is to increase retention in engineering by providing an improved calculus experience with a minimal amount of institutional change and costs.

**Methods & Strategies:** We are augmenting calculus with real world engineering problems, using modules and mentors as vehicles to deliver engineering content to engineering students in calculus. The modules are composed of a series of self-contained engineering problems that highlight important calculus concepts. Students meet in small groups to discuss the modules. Group discussions are facilitated by upper-level engineering students.

**Evaluation Methods & Results:** Project evaluation efforts rely on observation from internal and external reviewers, student satisfaction surveys, focus groups, and structured record reviews of students’ success in the module lessons as well as in the overall course.

**Dissemination:** We have Published 4 papers in three the following journals: American Society of Engineering Education Annual Conference, June 2012, (to appear); Institute of Electrical and Electronics Engineers Annual Global Engineering Education Conference, 2012; IEEE International Conference on Frontiers in Education: Computer Science and Computer Engineering, July 2011, pp. 167-172; American Society of Engineering Education Annual Conference, June 2011, AC 2011-586; and some of the modules are published on an interactive website established and maintained by the PIs.

**Impact:** To eliminate the loss of talented engineers due to a negative perception and fear of math/calculus courses. The projects’ methods serve as a model for other instructors to use to increase student retention.

One crucial impact we hope to achieve is the retention of a greater number of ethnic minorities and female students. This project can improve the quality of teaching at UND and other universities by implementing the mentoring program and modules that are developed by this project.

**Challenges:** The most significant challenge to the proposed work was handling the administrative issues related to the Summer Bridge Program. Our objective was to offer a risk-free opportunity outside the standard course structure. Unfortunately, the Administration did not have the needed
mechanisms in place to offer such a program. This meant that students interested in the Bridge Program had to register for an official course. Offering the Bridge Program as a summer course generated additional issues such as obtaining a course number. To remedy the problem the mechanism by which the Bridge Program was offered was altered, while it structurally remained the same.

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**PI:** Spencer Kim  
**Institution:** Rochester Institute of Technology  
**Project Title:** Transforming Curriculum for Workforce Development in Green Plastics Manufacturing Technology  
**Project Number:** 1044794  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The goal of the project is to transform the existing materials and manufacturing curriculum to keep pace with the green plastics manufacturing technologies. The outcomes are to develop and pilot test an educational approach and undergraduate teaching modules for green plastics manufacturing technology.

**Methods & Strategies:** We enhance current core courses (materials technology, mechanical engineering technology lab II, plastics processing technology, solid modeling and design, and robotics in manufacturing) with new modules in green plastics manufacturing technology and adopt “Process Oriented Guided Inquiry Learning” (POGIL) techniques to promote active, project/ research-based learning.

**Evaluation Methods & Results:** The purpose of the student survey was to investigate how students felt about their experiences after completion of the class works. In the fall of 2011, a total of 22 students were enrolled in the materials technology course and met the four sessions (a 50 min per session) a week; one session was spent doing the online quiz and student survey. The total of eight surveys was anonymously asked to the students in order to monitor change in their learning experiences in class for the POGIL activity over the 10 weeks. Students showed positive perceptions and attitudes for the new instructional model and re-designed curriculum modules in materials technology; among students the strong agreement was a range between 7% and 29%, and the agreement was a range between 67% and 75%, approximately.

**Dissemination:** We have presented some outcomes, product, and activities on Facebook: http://www.facebook.com/pages/Green-Plastics-Manufacturing-Technology-GPMT/137107806352893. Also, we will develop a web link to disseminate all outcomes and present some work at the 2012 ASEE annual conference.

**Impact:** We are expecting to produce the optimal methods of instruction to bring desired outcomes in knowledge and skills in green materials technology for undergraduate students in the engineering technology programs. We will continually monitor our outcomes and modify the instructional model as needed until it reaches the teaching goals for STEM. We expect the new approach in teaching to attract a diverse student body in the manufacturing, mechanical engineering technology and packaging science programs.

**Challenges:** N/A

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**PI:** Nikos Kiritis  
**Institution:** McNeese State University  
**Project Title:** A Model Portal for Pre-Engineering  
**Project Number:** 0942227  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Enhance the pre-engineering curriculum at McNeese State University and establish a pre-engineering program on the LSU-Eunice campus (community college). Increase the understanding of pre-engineering course concepts. Increase student processing skills required for pre-engineering problem solving. Improve student attitudes about engineering as a field of study and a profession. Promote engineering as a career to students in the rural central Louisiana area.

**Methods & Strategies:** We are proposing to meet our goals by redesigning ENGR 207 Thermodynamics, ENGR 211 Circuits, and ENGR 301 Engineering Statics using an activity-based, hybrid approach. Our approach is comprised of three components, a) face-to-face (live and virtual), b) web-based, c) on site support.

**Evaluation Methods & Results:** Three evaluation loops will be implemented to ensure continuing improvement on the pedagogy behind the modules and the quality and appropriateness of the scientific content of the developed materials. The first loop involves the MSU co-PIs (module authors) and the LSU E co-PI. The second loop involves the MSU co-PIs and external subject matter experts (engineering professors throughout the country with extensive experience in teaching pre-engineering courses). The third loop evaluates the student competencies as they are developed during the semester.

**Dissemination:** Upon completion of the pre-engineering program, it is our intent to expand it to other institutions within our service area. Louisiana State University at Alexandria (LSUA) and Lamar State College Orange, Texas (LSCO) have expressed an interest for a pre-engineering program to be delivered to their campuses. In addition, if this web-based instruction is
proven successful, there is a significant opportunity to expand the program to other STEM courses.

**Impact:** We achieved a closer collaboration between our four-year institution and our partner community college and were able to successfully acquire, install and use technology to deliver engineering courses to the community college. Many of our students experienced for the first time a learning environment where remote students are integrated in the learning process.

**Challenges:** The opportunities to cheat with online evaluation instruments presented definite problems that we must address further. Dealing with underprepared students in math and physics posed challenges that we had to address with additional out of class recitation sessions. Students are transferring out of the community college to four-year institutions prematurely (before taking calculus and calculus based physics and becoming ready to enroll in our engineering courses).

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**PI:** Nathan Klingbeil  
**Institution:** Wright State University  
**Project Title:** A National Model for Engineering Mathematics Education  
**Project Number:** 0817332  
**Type:** Phase 3/Type 3 - Comprehensive  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** The inability of incoming students to successfully advance past the traditional freshman calculus sequence is a primary cause of attrition in engineering programs across the country. As a result, this project seeks to effect a transformative and nationwide change in the way engineering mathematics is taught.

**Methods & Strategies:** The Wright State model involves the introduction of EGR 101 - a hands-on, application-oriented freshman engineering mathematics course - along with a substantial restructuring of the early engineering curriculum. This Phase 3 project includes pilot adoption and assessment of the approach by 15 institutions across the country.

**Evaluation Methods & Results:** Assessment at Wright State University and its collaborating institutions includes both quantitative and qualitative measures of student retention, motivation and success in engineering. Results from each institution are being consolidated and externally evaluated by a national expert in engineering education, and are intended to provide the pedagogical basis for widespread adoption of the approach. To date, results of student surveys have revealed an increased motivation and perceived chance of success in future math and engineering courses. This has been accompanied by significant increases in student retention and success in engineering, from first-year through graduation.

**Dissemination:** All course materials and recent program publications have been made available at http://www.engineering.wright.edu/cecs/engmath/. Through invited presentations at conferences, workshops and a variety of academic institutions, the PI has established well over 200 contacts from dozens of engineering programs across the country.

**Impact:** The project team of 15 diverse institutions (primarily university but also at the community college and K-12 levels) spans strategic pockets of interest in Ohio, Michigan, Texas, Oklahoma, California, Washington, Maryland, and Virginia, and forms the critical mass required to effect a transformative and nationwide change. Expected long-term impacts include significant increases in engineering student retention and graduation rates at universities across the country, as already realized at the lead institution. By increasing the accessibility of the engineering curriculum, the Wright State model is also expected to have a profound effect on recruitment and retention of traditionally high-risk students.

**Challenges:** The only unexpected challenge associated with this project has been its exponential growth. What started as a fix for engineering student attrition at Wright State University has sparked interest not only from universities across the country, but also from community colleges and the K-12 arena. We have dealt with this growth by establishing a strong team of national players in each of these areas. At Wright State, we are dealing with the local demand for EGR 101 in the community college and K-12 arenas by the expanded employment of undergraduate teaching assistants, which sets the stage for their future recruitment to our own graduate programs.

**183**

**PI:** Milo Koretsky  
**Institution:** Oregon State University  
**Project Title:** Collaborative Research: Integration of Conceptual Learning Throughout the Core Chemical Engineering Curriculum  
**Project Number:** 1023099  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** The goal of this project is to create a community of learning within the discipline of chemical engineering (Che) focused on concept-based instruction. The project will develop and promote the use of a cyber-enabled infrastructure, the AIChE Concept Warehouse, which ultimately could be used throughout the core Che curriculum. Conceptual questions, both as Concept Inventories and Concept Tests, will be available.

**Methods & Strategies:** A flexible database-driven approach will be used to form the AIChE Concept Warehouse. This innovative approach allows conceptual questions to be developed, linked, and integrated on an item-based level, allowing versatility in
use, including both in assessment and in instruction. The software will allow interactive electronic use, as well as PowerPoint, Word, and pdf formats to be automatically generated so that conceptual learning and evaluation can be incorporated into instruction in various forms.

**Evaluation Methods & Results:** The AIChE Concept Warehouse development will primarily be assessed based on metrics of use and activity. Faculty will have unique login information to the site so that use can be tracked. The merits of the innovative, curricular integration feature will be evaluated in terms of semi-structured interviews with instructors who use the warehouse in this manner. Currently, the AIChE Concept Warehouse has more than 1,200 concept questions available for searching, viewing, and using in courses through the user interfaces. Student and instructor interfaces are available at http://cw.edudiv.org for the community, and university faculty can obtain an account through this site. Beta testing of the AIChE Concept Warehouse began in November 2011, and is currently underway.

**Dissemination:** In order to foster community engagement, two types of activities have either started or are planned for the future. These types of activities include professional society related activities (e.g., special sessions, posters, papers, and presentations) and independent department visits. At the 2011 ASEE Annual Conference, a special session was presented. This interactive special session had approximately 70 attendees and lasted 90 minutes.

**Impact:** This project will form a bridge between chemical engineering researchers developing Concept Inventories and Concept Tests and chemical engineering educational practitioners in the classroom. An important aspect of this project is to develop access to teaching materials so that faculty can change the way they teach and implement more effective teaching methods without taking additional time away from the many other demands on their time. Through concept-based instruction, students will become more facile in applying core concepts to real situations, and they will become more adaptable problem-solvers. This project will lay the groundwork for implementing a widespread transformation of chemical engineering education towards concept-based instruction and learning with understanding.

**Challenges:** While we have previous experience with this type of software development, it has been used exclusively at the home institution. This project requires both versatile and intuitive user interfaces. To deal with this, we have developed a 5 step design process: (1) Developing a function list to be incorporated into the page; (2) Creating a storyboard of a page that includes the listed section functions; (3) Implementing the storyboard concept in a live webpage; (4) Design team testing of live webpages and modification to enhance functionality and usability; and (5) External testing of live webpages and modification to enhance functionality and usability. The contrast in attendance between the ASEE special session and the AIChE workshop is reflective of the challenge in attracting mainstream faculty to education reform.

**184**
**PI:** John Krupczak
**Institution:** Hope College
**Project Title:** Technological Literacy: Assessment and Measurement of Learning Gains
**Project Number:** 1121464
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** Measure technological literacy among undergraduate students; develop shared assessment tools and related standard learning outcomes; and measure how increased technological literacy impacts individuals in their daily lives beyond the classroom.

**Methods & Strategies:** The project will develop assessment tools based on existing course assessments used by faculty. The plan is based on the approach that suitable assessments of technology literacy might be developed through modification or adaptation of existing course assessments.

**Evaluation Methods & Results:** The main outcomes to be evaluated are:
- Were the participants able to use the project assessment tools in their courses?
- Did the participants find the tools valuable as assessments of learning outcomes in their courses?
- Are educators who were not project participants considering using the assessment tools developed in this project?

**Dissemination:** Dissemination will target the Membership of the Technological Literacy Division of the American Society for Engineering Education. All members will be contacted through multiple methods to provide information about the assessment methods developed.

**Impact:** The impact of this work will be furthering an understanding of how to measure gains in technological literacy among undergraduate students. Impact will also occur from applying these assessment tools to a population of students who are enrolled in technological literacy courses across a range of institutions, thus reporting some initial data measuring the technological literacy of undergraduate non-STEM students.

**Challenges:** Coordinating application of assessment methods across institutions has been unexpectedly challenging. However through an increased level of communication between project participants this challenge is being addressed.
**185**  
**PI:** Sanjeev Kumar  
**Institution:** SIUC  
**Project Title:** C2P2 Oriented Laboratory Instruction in Geotechnical Engineering using Digital Videos and Evaluation of its Impact on Students' Learning  
**Project Number:** 0736819  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Significantly enhance the quality of geotechnical engineering laboratory instruction to the primary target audience by developing high quality videos of common laboratory tests relating the tests to professional practice.

**Methods & Strategies:** Developed several DVDs which have been reviewed by several faculty members and students.

**Evaluation Methods & Results:** Evaluation of the project has been done by conducting the following surveys:
- Students who watched the DVDs
- Pre and Post tests
- Primary Instructors
- Teaching Assistants

**Dissemination:** The completed DVD are likely to be distributed by American Society of Civil Engineers (ASCE).

**Impact:** The primary target audience for the project includes civil engineering students in two-year and four-year degree programs, as well as engineers and technicians entering the workforce. The secondary audience includes students and practicing engineers in underdeveloped countries who often do not get an opportunity to see even the basic equipment because of lack of resources. The educational material developed provide an opportunity for gaining knowledge of the most important topics in Civil Engineering to all, irrespective of their gender, disability, and geographic location, and irrespective of when, where, and how they decide to learn. Successful completion of the project will provide significantly enhanced laboratory instruction which is complete, consistent, and imparts a sense of civic responsibility in students’ minds. Several faculty members who have limited experience in professional practice and laboratory experiments would also enhance their skills by learning from the proposed educational material.

**Challenges:** None at this time

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**186**  
**PI:** Amy Landis  
**Institution:** Arizona State University  
**Project Title:** Integrating Sustainability into the Civil Engineering Curriculum Through Three Courses at the University of Pittsburgh

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**187**  
**PI:** Oenardi Lawanto  
**Institution:** Utah State University  
**Project Title:** Promoting Metacognitive Knowledge and Shared Note-taking to Learning Electric Circuit Concepts Through Enhanced Guided Notes  
**Project Number:** 0942942  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The ultimate goal of this project is to develop a new type of instructional materials and strategies for use in an electric circuit course for non-electrical engineering majors. Outcomes of this project are intended to help students utilize lecture time more effectively for learning and to improve note-taking skills.
Methods & Strategies: This project employs a design-based research approach, which blends empirical educational research with the theory-driven design of learning environments. As we utilize the approach for this project, we intend to make continuous improvement throughout project phases. The development activities are mainly focused on our efforts to continue improving the enhanced guided notes (EGN).

Evaluation Methods & Results: External project evaluation involved multiple observations of leadership team meetings, class lecture and laboratory activities, and formal interviews with students and research team members. Results indicated that research team members are fulfilling their responsibilities in a timely manner, EGN are perceived to be useful, and regularly being used successfully in classes and labs. The evaluator recommends that the leadership team consider developing and assessing a variety of implementation protocols or guidelines for instructors and students. These guidelines, refined through multiple design, implementation and testing cycles, may serve to increase the perceived value and utility of metacognitive activities.

Dissemination: The project findings have been disseminated at conference events. One paper has been presented and published at the Frontier in Education conference (FIE) 2011. Two papers have been submitted for the FIE 2012. In addition, two journal papers are under preparation for submission. In addition, the researcher plans to share project findings and materials on a dedicated website.

Impact: According to the researcher's experience and student feedback, metacognitive prompts in the EGN helped students to engage in learning process. The researcher improved the prompts by decreasing the prompt repetition and contextualizing the prompts based upon the topic. Furthermore, learning by doing has proven to be a good method for mentoring my graduate student. This project improves his understanding on metacognition in an engineering design context. To increase impact of this project, researcher is planning to develop a website to share information related to this project and to open potential collaboration with researchers from other institutions. This project might contribute to educational psychology field (e.g., cognition/metacognition and self regulated-learning).

Challenges: Developing a metacognitive instrument for a new context (i.e., engineering) is a complex task. To deal with this challenge, we used Butler and Cartier's self-regulated learning model as a framework and created questionnaire items by investigating students' learning activities. Furthermore, as we received suggestions from our informal collaborator, we modified the experimental design. The reason was metacognitive abilities change at a slower rate than was originally thought. In the original research design, the students were randomly divided into two groups and each group was exposed to a different treatment. At the midpoint of the semester, the treatments were swapped between the groups. The decision was to only expose each group of students to one treatment.

188
PI: Kemper Lewis
Institution: University at Buffalo/SUNY
Project Title: Collaborative Research - Teaching the Global, Economic, Environmental, and Societal Foundations of Engineering Design Through Product Archaeology
Project Number: 0920259
Type: Phase 2/Type 2 - Expansion
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: By considering products as designed artifacts, our goal is to synthesize concepts from archaeology with advances in cyber-enhanced product dissection to implement new educational innovations that integrate global, economic, environmental, and societal concerns into engineering design-related courses using product archaeology. While our initial outcomes will primarily be focused on engineering design-related courses, we will develop exercises that can be easily adapted to a wide range of courses in many engineering departments.

Methods & Strategies: We are creating integrative in-class activities and learning materials for product-based archaeological exercises that help address global, economic, environmental, and societal concerns in engineering design-related courses that span freshmen through senior levels; and developing and formalizing rubrics and assessment tools in our four core areas to ensure sustainable deployment with national impact.

Evaluation Methods & Results: Our evaluation plan has included measures to assess the impact of our product-based archaeological exercises on student learning at our four institutions (University at Buffalo SUNY, Penn State University, Northwestern University, and Arizona State University), as well as measures to document the impact of our materials on the broader engineering education community. Student responses to the assessments along with expert evaluation of student work serve to both evaluate performance as well as student insights into the role that global, economic, environmental, and societal factors play in design practice and the engineering profession. Results have indicated a significant impact on student perceptions and learning, and their global, environmental, societal, and economic understanding and awareness.

Dissemination: We have conducted hands-on workshops to foster dissemination of new teaching strategies based on product archaeology through faculty development and outreach, including summer high school workshops for females.
The first two high school workshops were in July 2010 and 2011, and the first faculty workshop was in August 2010. We plan to continue to expand our faculty outreach activities and expand our K-12 outreach into the middle school years.

**Impact:** By leveraging our current National Cyber-Collaboratory, which has already involved nearly 5,000 students and over 30 faculty members, this project is essentially establishing the foundation the next 20+ years of transformative educational innovations and research built upon product archaeology. Sustainable new courses and course modules across mechanical engineering departments at multiple schools have been achieved. Also, future faculty workshop attendees will receive one well-developed sample curricular unit for each focus area global, economic, environment, and economic training on how to use the units in their classroom with their students. The aim of the faculty workshop assessment is to document how well our materials have been disseminated and to understand the factors that facilitate or impede the adoption of the materials. Lastly, in the high school workshop, we will also evaluate to what extent the activities influence the students' decisions to pursue engineering majors.

**Challenges:** Assessing students' understanding and perceptions of global, environmental, societal, and economic issues in product design creates instructional and assessment challenges. We are leveraging the assessment instruments from the Prototype to Production (P2P) project funded by NSF, and have aligned some of our assessment instruments with the NAES’s recent Engineer of 2020 envisioning material. We have also implemented 1-minute elevator presentations and competitive wiki-based and Facebook-based archeological product digs.

**Evaluation Methods & Results:** Mechanix-Truss has been implemented into a freshman engineering class. A control group is compared to a group using Mechanix. A mixed method approach of focus groups, concept inventories, attitude surveys, quizzes and exams is measuring the impact on student learning and opinions.

Results have shown that students are very excited about Mechanix and exam scores are improved when students use Mechanix for at least half their homework.

**Dissemination:** A workshop on Mechanix is being offered at the 2012 ASEE Annual conference. Conference papers have been published at ASEE and FIE. A link to use Mechanix will be posted on a website.

**Impact:** Mechanix-Truss shows great potential for improving student learning of the methodology of joints for truss analysis and free body diagrams. The technology appeals to students. Mechanix is also being implemented at LeTourneau University.

**Challenges:** Mechanix requires significantly more testing and debugging than expected. We are introducing Mechanix to other classes to provide users with both their feedback and as an avenue to identify bugs.

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**190**

**PI:** Michael Loui

**Institution:** University of Illinois at Urbana-Champaign

**Project Title:** Enhancing the ECE 101 Curriculum Through Diversity Harnessing

**Project Number:** 0942331

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The goals of this project are to (a) better engage students in the course topics, (b) quickly integrate diverse student-driven subject matter back into the course, and (c) empower the students to more effectively apply new skills to their lives and careers.

**Methods & Strategies:** Through cooperative learning and online assignments, the instructor regularly collects student ideas in the form of minimally-biased questions and subsequent generation of assignments.

**Evaluation Methods & Results:** For the first goal (a), we have and will continue to administer the Student Course Engagement Questionnaire, SECQ (Handelsman, Briggs, Sullivan, & Towler, 1998) three times during the semester. For the second goal (b), we will examine how submitted answers to the diversity harnessing questions are mapped to new exercises. For the third goal (c), we have conducted cross-sectional interviews with 12 students, and we will continue to conduct longitudinal interviews with about 10 students.
Dissemination: We presented a short paper at the Frontiers in Education Conference in October 2011. We submitted a full paper to the ASEE Annual conference in June 2012. In summer 2012, exercises that show the mapping of student ideas into assignments will be archived.

Impact: Students benefit from ECE 101 beyond simply fulfilling a general education requirement: their self-efficacy with challenging technical projects appears to improve. Students have also told us that ECE 101 was useful in obtaining jobs after college. We hope for more explicit examples of where students applied directly knowledge gained from ECE 101 to a task. Our process for engaging non-engineering students has been publicized on campus: http://www.i stem.illinois.edu/news/ECE101.html.

Challenges: Few students from Fall 2011 volunteered for the longitudinal interviews for the evaluation, despite the $10 compensation. We will invite students enrolled in ECE 101 in Spring 2012 prior the semester’s end for interviews. The use of online assignments led to an unexpected decrease in student collaboration. We alleviated this problem by splitting the weekly homework into an online portion and a handwritten portion. The instructor was challenged to create appropriate diversity-harnessing exercises.

191
Pi: Hong Man
Institution: Stevens Institute of Technology
Project Title: SimuRad A Software Simulation Environment for Medical Imaging Education
Project Number: 0633522
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The objective of this project is to develop a computer simulation lab environment that can help junior or senior undergraduate students from different majors to understand the concepts and theories of medical imaging methodologies.

Methods & Strategies: We developed a software suite that contains a series of computer lab exercises. Currently implemented modules include math fundamentals, computed tomography (CT), x-ray physics, nuclear magnetic resonance (NMR), image enhancement and analysis.

Evaluation Methods & Results: Our assessment of students’ learning experience is mainly based on student surveys. We designed a simple set of survey questions for students to complete after each lab exercise. The survey was voluntary. The questions include the scales of student’s understanding of a certain concept before and after the lab exercise, the scale of knowledge preparation for the lab exercise, the time spent on the lab exercise, and the need for lab design improvement.

Dissemination: We have published four papers at ASEE Annual Conferences (2009, 2010, 2011 and 2012). We also have reported our progresses at two CCLI PI conferences (2008 and 2011).

Impact: We started the deployment and assessment of these lab exercises in Fall 2008, and by Spring 2012 we have obtained the assessment results for four consecutive years. The results generally indicate that this software is a helpful learning tool and its usability is satisfactory.

Challenges: A major challenge of this project is the maintenance and update of the software. We eventually migrated into a commonly used platform, Matlab, and opened up the code for students to explore and update.

192
Pi: Timothy Matis
Institution: Texas Tech University
Project Title: Collaborative Research: Stochastic Challenge
Project Number: 1044133
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Develop a set of educational materials for the undergraduate instruction of stochastic processes, including videos, wiki-tutorials, and calculators. These will be hosted on a website www.stochasticchallenge.org and linked via a Facebook page. The website will also support the modeling side of stochastic processes to aid in the use of the material in real world applications.

Methods & Strategies: The videos will be produced through collaboration with industry to create a context for learning academic topics, and last about four minutes in length. The use of wiki-tutorial will allow students to refine and add to the material to customize for student learning styles.

Evaluation Methods & Results: The project is being evaluated by Doug Timmer of UnivTexas PanAm. The project evaluation plan consists of 3 stages, planning, formative, and summative. The planning part was prior to the project starting to ensure all materials and approvals needed are in place. The formative part will consist of focus groups and surveys, which will be used to refine the project materials created. The summative part will be based on pre-post surveys and tests to gauge the effect of Stochastic Challenge on learning. These will be conducted at Texas Tech University and Missouri S&T University.

Dissemination: The project will be disseminated through the usual channels of journals, presentations, etc., but in addition through the novel use of electronic media. A Facebook page will be created for Stochastic Challenge and we will actively try to ‘friend’ students to the site.
Impact: The primary audience that will be impacted by this work are undergraduate students at all institutions of higher learning. The work is meant to be incorporated into student learning, and course adoption is not necessary. Students will be drawn to this work through the quality of information housed on the website, and the marketing of the website through active electronic media methods. It is anticipated that over time, faculty will direct students to this site as a repository, and will use the materials in their lectures.

Challenges: The project is still in its early stages, but one problem we have had is in finding students that are qualified to work on this project. In particular, it has been difficult finding an intern for the summer months from a HSI university. Our approach has been to contact professors at the universities and ask them directly for contact information of a student that might be interested in this work.

**193**
PI: Michael Mauk
Institution: Drexel University
Project Title: Lab on a Chip: Integrating Microfluidics into the Engineering Technology Curricula
Project Number: 1044708
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Microfluidics Lab on a Chip is an emerging and increasing important technology for sensors, MEMS, and biomedical applications. Students will gain a broad understanding and hands-on experience with designing, prototyping, and testing micro-scale fluidic processing systems.

Methods & Strategies: We are integrating microfluidics into undergraduate engineering and technology curricula by developing and validating microfluidic-based laboratories and projects that can be incorporated into contemporary engineering courses such as fluid mechanics, heat transfer, CAD, rapid prototyping, robotics, metrology, and sensors and instrumentation, as well as serve as Senior Design Projects.

Evaluation Methods & Results: Students develop and characterize microfluidic chips, the performance of which can be readily tested. Successful demonstration and operation of microfluidics experiments will be diagnostic for student learning. In addition, we survey the students for their understanding of the material and their perspective on its relevance.

Dissemination: In Year 1, our dissemination efforts related to selecting low-cost, readily available materials and instrumentation so that educational institutions could readily adapt the laboratory. We developed and hosted lab sessions for students from a remote campus site indicating the portability/transferability of these activities to other schools. We also supported high school science teachers to develop microfluidics-based experiments for secondary schools.

**194**
PI: Kathleen Meehan
Institution: Virginia Polytechnic Institute & State University
Project Title: Lab-in-a-Box: Development of Materials to Support Independent Experimentation on Concepts from Circuits and Electronics
Project Number: 0817102
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Increase student comprehension of concepts in circuits and electronics; develop activities that promote self-learning; increase ability to perform experimental research; develop best practices on teaching strategies to integrate hands-on activities; and perform formative assessments.

Methods & Strategies: Create learning materials and teaching strategies; develop multimedia modules; expand Lab-in-a-Box into other courses at VT, VWCC, and elsewhere; develop online lab course; assess student achievement; conduct research on multimedia materials; and disseminate learning materials.

Evaluation Methods & Results: Conduct student surveys prior to and after hands-on learning activities and use course evaluation data from ABET self studies. Results from the student surveys have been mostly positive, though there are areas in which improvements are needed. Results were documented in an ASEE 2011 presentation and conference paper.

Dissemination: Demonstrations have been carried out at Conference on Higher Education Pedagogy (2010), VA Engineering & Technology Peer Group meeting (2011), and ECEDHA Expo (2011, 2012). Ten conference papers have been given at various ASEE and FIE conferences. An ASEE workshop is planned in June 2012.
Impact: There are approximately 675 ECE and ME students enrolled in Lab-in-a-Box courses per semester at VT. Approximately 30-100 students at three VA community colleges take similar courses. Hands-on activities have been introduced into VT EM, controls, and signal/system courses. UVA adopted the approach in their distance learning engineering program. Other schools are actively considering using similar approaches. Materials are available at www.lab-in-a-box.net.

Challenges: Resources limit the expansion of Lab-in-a-Box activities at VT and VWCC. The time and personnel required to grade the large number of student reports is considerable. There has not been much staff and faculty time to develop robust instructional materials for hands-on activities, which has restricted the adoption of hands-on activities in a number of courses. Development of automated grading programs has helped with some of these challenges.

195
PI: William Oakes
Institution: Purdue University
Project Title: Collaborative Research: Assessing Individual Ethical Reasoning and Team Ethical Climate: Understanding their Relationship in Undergraduate Design Teams
Project Number: 1123323
Type: Phase 2/Type 2 - Expansion
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The goal of this project is to 1) develop instruments which reliably and validly measure individual ethical reasoning and team ethical climate, 2) track their growth in undergraduate student design teams, and 3) investigate the relationship between individual and team ethical climate.

Methods & Strategies: The reliability and validity uses mixed-methods that include reliability analyses, structural equation modeling, interviews and observations. In addition, a hierarchical linear modeling (HLM) approach will be utilized to analyze the influence of teams on individuals.

Evaluation Methods & Results: The evaluation work for this project includes five components: collaborative effort, annual visits, monitoring of the research process, monitoring of the instrument development process, and report writing. We have just concluded a visit to evaluate the first two semesters of work. We are completing the initial data collection from the assessment instruments and convergent data, and will be analyzing the data this summer. A data collection plan will be developed this summer which will guide the next year’s data collection.

Dissemination: We plan to communicate the results within engineering education, service-learning and the ethics communities at conferences and in peer-reviewed journals. In addition, products will be made available through the NSF-sponsored National STEM Digital Library.

Impact: Better understanding the development of ethical reasoning and team ethical climate can greatly enhance the way engineers and other technical professionals learn key attributes called for by ABET, the NAE’s Engineer of 2020, and industry stakeholders. To develop curricula that nurture and develop these skills in students, faculty need to be able to assess the impact of their courses. This study is the first step in that process by providing valid and reliable measures and correlations between individual development and team climate.

Challenges: We had developed drafts of the instruments prior to the start of the grant that we thought we would be able to use without much further development. However, the initial validation studies indicated that additional development was needed, which delayed the initial data collection by a semester. However, we are collecting more samples in the first administration to improve the analyses that we can conduct this summer to compensate for the slight delay in schedule.

196
PI: Matthew Ohland
Institution: Purdue University
Project Title: SMARTER Teamwork: System for Management, Assessment, Research, Training, Education, and Remediation for Teamwork
Project Number: 0817403
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: Helping students be effective members of teams; helping faculty learn to be effective managers of team activity; and helping the researcher study teamwork.

Methods & Strategies: Deploy tools that give faculty and students feedback on team dynamics and team member effectiveness. Develop training materials for students and faculty to help them develop and improve these skills. Capture team data of interest to researchers. Provide feedback useful for program evaluation and accreditation.

Evaluation Methods & Results: Widespread adoption and accelerating adoption rates of online tools support a behavior change in faculty and the relevance and ease of use of the system. Surveys of users have provided reaction data indicating significant satisfaction with the online tools. The survey data also indicate changes in faculty practice supported by the use of the online tools. Through a longitudinal study of the change in self-rating vs. rating by others, there is some support for the assertion that students who use the system repeatedly develop both expertise in rating and competence as team members.
Poster Abstracts

Dissemination: The online tools have been publicized through workshops, invited talks, conference presentations and symposia in different fields, brochure distribution, and word of mouth.

Impact: Over 90,000 unique students have used the system at over 400 faculty taking classes by over 1800 faculty who have accounts on the system. Use of the system at Purdue is expanding to affect first-year engineering, multiple disciplines of engineering, and the School of Management.

Challenges: The software developer supporting system maintenance and the development of additional features to support students, faculty and researchers has been retained by the FBI for computer forensics, so he has had to subcontract the scheduled work, resulting in delays, loss of single-source coordination, and some lapses in reliability.

197
PI: Selahattin Ozcelik
Institution: Texas A&M University-Kingsville
Project Title: Laboratory-Based Robotics Program at TAMUK
Project Number: 0942932
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: Prepare students for the contemporary robotics field by developing a laboratory based competition driven two semester robotics curriculum. Better project skills; project management, leadership, problem solving, communication and teaming, will be attained.

Methods & Strategies: A two-course robotics curriculum was developed and offered jointly by the Mechanical and Electrical Engineering Departments. Curriculum content and development stages were aligned with the IEEE student robotics competition. Students perform outreach by conducting peer-mentoring activities.

Evaluation Methods & Results: Formative and summative evaluation are being implemented through both internal and external evaluation tasks. The results have been evaluated by using two class surveys, the high school mentoring survey, and the outreach day survey. The program was successfully developed and implemented at TAMUK. The curriculum evaluation by four surveys showed that the program with proper support for hands-on laboratory activities was very effective to stimulate student interests towards robotics.

Dissemination: Presenting teaching activities and research project results in ASEE Annual conference. Students mentored high school student teams for BEST Robotics Competition. Gave presentations at an area college and high school. The robotics club was formed as an official student organization. Robotics day activities were broadcasted on a local news channel.

Impact: It has been observed that a robotics curriculum in creative, competition-driven environments with extensive support highly improved student accomplishments. Successful robot design indicated increased knowledge, design, and project management skill levels in robotics field. Better project skills attained by students through interdisciplinary team projects. Evaluation results show that there is an increased interest in robotics among college and high school students.

Challenges: Management of outreach activities, communications with area high schools was unexpectedly challenging and time consuming, (e.g. Scheduling conflicts between student mentors and high school robotics teams, communication with high school coaches and feedback from them). New approaches are being considered to overcome these difficulties.

198
PI: Christopher Papadopoulos
Institution: University of Puerto Rico Mayaguez
Project Title: Leveraging Simulation Tools to Deliver Ill-Structured Problems: Enhancing Student Problem-Solving Ability in Statics and Mechanics of Materials
Project Number: 1044866
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: (1) Accelerate development of engineering student expertise to solve design problems; (2) Advance students' simulation competency; (3) Advance use of longitudinal assessment to measure long-term impacts of new pedagogy.

Methods & Strategies: Develop new teaching modules for Statics and Mechanics of Materials that will be vertically integrated and based on using simulation tools. A panel of experts has been recruited to help select problems and simulation platform via a Delphi process.

Evaluation Methods & Results: A cohort has been recruited to take a four-course sequence of consecutive classes for longitudinal assessment. Student attitude and performance will measured during the two intervention courses (Statics and Mechanics of Materials), and ‘downstream’ in two subsequent courses in which no interventions are proposed (Advanced Mechanics of Materials and Structural Analysis).

Dissemination: A poster was presented at the NSF Engineering Education Awardees Conference in March. Another poster will be given at the NSF Poster Session in June at the ASEE conference.

Impact: Anticipated impacts: Students will (1) deepen conceptual knowledge of mechanics, particularly in topics targeted by the expert panel (in progress); (2) become exposed
to design, 'what if' problems, and other ill structured problems; (3) learn the value of simulation to solve complex problems and to validate classical results from textbooks, and conversely, use classical results (and other methods) to validate solutions from simulations. Faculty will (4) become more comfortable using simulation software as tools, without feeling the need to first 'derive everything'; and (5) have practical modules that they can employ in their courses.

Challenges: (1) some complexity in designing graphical user interfaces to simplify the running of FE software (e.g. SolidWorks); (2) the feedback from the expert panel proceeded somewhat slowly; (3) some errors were made in recruiting students through the university's enrollment process, so some post hoc rearrangements of students' schedules after the enrollment period were necessary.

199
PI: Ian Papautsky
Institution: University of Cincinnati
Project Title: Collaborative Research: Microfluidics for Multiple Engineering Disciplines
Project Number: 0814911
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goal of this project is to adapt and implement a successful pilot course for teaching microfluidics (which is a multidisciplinary field encompassing engineering and biotechnology).

Methods & Strategies: Course materials developed at Univ. Cincinnati are modified at each participating university based on student population and existing curriculum. Assessment includes meta-analysis of questionnaires and focus groups at each location.

Evaluation Methods & Results: Evaluation includes assessment of effectiveness of introducing engineers from multiple disciplines to microfluidics as well as the effectiveness of the course implementation. Assessment is being conducted using quizzes, anonymous paper-based questionnaires, and small focus group interviews by a third party evaluator. Preliminary results after the three rounds of instruction indicate successful implementation of the pilot course from Univ. Cincinnati at four institutions.

Dissemination: The course has been described in several peer reviewed educational publications and presentations including the ASEE and IEEE FIE meetings. A text book for commercial distribution is being considered.

Impact: To date, nearly 100 engineers have participated in the course. Preliminary results suggest a strong positive impact of the project. The anticipated impact is that the students will be better prepared to pursue graduate work and to meet the needs of industry and government employers in the microfluidics area, which is projected to grow tremendously in the next decade.

Challenges: No major challenges encountered yet, although preparing a text book for commercial distribution will be challenging.

200
PI: Hirak Patangia
Institution: University of Arkansas-Little Rock
Project Title: Development of Novel Learning Materials for Green Energy Education Centered Around A Photovoltaic (PV) Test Station
Project Number: 0942327
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The primary goal of the project is to develop exemplary learning materials and lab modules for PV (Photovoltaic) engineering at the undergraduate/graduate level, and field test for evaluation and assessment. Development of a lab facility for providing practical experience is also an intended outcome.

Methods & Strategies: The course materials are based on available literature including journal and conference articles, and PI's personal experience in this field. The lab modules will be derived from PI's research experience and project-oriented hands-on activities will be an integral component of learning experience.

Evaluation Methods & Results: A preliminary version of the course was field-tested in the summer with five students including a graduate student. Although a small sample, the students' assessment result is excellent. Formative assessment is used to assess the usefulness and relevance of the course modules in contexts to lab experience and engineering needs. An education specialist will use online surveys to get student feedback to align the modules to intended outcomes and also with input from the IEEE power group. Summative assessment will involve an overall assessment of learning effectiveness and the lab facility.

Dissemination: Published three peer-reviewed articles: one at ASEE-2011 conference (NSF session) and two at IEEE international conferences. One paper for ASEE-2012 conference is accepted for the NSF session and two other articles are under review. Course modules will be posted on the web upon project completion.

Impact: The first offering of the modules has created high enthusiasm among students for the course which is the first of its kind at this institution. The completion of the lab has impacted the university by providing a modern lab for teaching/research. The university provided the dollars to acquire the
basic instrumentation and NSF funding has enhanced the lab through solar panels and feeding the PV voltage to the lab stations for real time testing. The lab facility has also impacted high school students through demonstration in outreach activities. The project will impact 40-60 students per year.

**Challenges:** No unexpected challenges. The project is moving on course and minor changes in budget allocation were made through consultation with NSF Project Director.

**201**

**PI:** Olga Pierrakos  
**Institution:** James Madison University  
**Project Title:** Design and Implementation of an Innovative Problem-based Learning Model and Assessment Tools in Undergraduate Engineering Education  
**Project Number:** 0837465  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The overarching goal of the project is to enhance undergraduate engineering education by promoting and implementing a new model of problem-based learning (PBL) as well as developing innovative assessment tools. Outcomes of the project include: (1) the development and implementation of a PBL classification framework, (2) the employment of a mixed-methods approach to assess engineering students’ learning outcomes (knowledge, skills, attitudes) during a broad range of PBL activities.

**Methods & Strategies:** We are grounding our work in problem-based learning (PBL) theory, research on problem solving, as well as motivational theories to develop, classify, and assess a variety of PBL activities in undergraduate engineering education.

**Evaluation Methods & Results:** We are using both qualitative and quantitative methods to collect data in classifying PBL activities and assessing student learning. We are finding that not all problems or PBL activities are created equal. Having developed a framework (based on problem complexity, problem structure, team structure, etc.) to classify problems, it is evident that the structure of the problem influences students’ learning outcomes greatly.

**Dissemination:** Dissemination to date has involved conference publications, both in the form of paper presentations as well as special sessions, at engineering education conferences. Dissemination of the PBL model, the classification framework, and the assessment tools to STEM faculty is also occurring at the institution of the PI.

**Impact:** Being a faculty member in a brand new engineering program (inaugural class started in Aug 2008), a major impact of this project has involved the integration of PBL practice and assessment in almost every class of our curriculum. The impacts to the students are immense because by exposing students to different types of problems, they are exposed to different ways of thinking, learning, and problem solving.

**Challenges:** A big challenge has been the translation of research (in the areas of problem solving and cognitive psychology) to curriculum development (involving the implementation and development of broad range of PBL activities with unique learning outcomes). In other words, a challenge (but also a big reward) has been working amongst disciplinary research boundaries. I dealt with this challenge by putting together an interdisciplinary research team (engineering educators, assessment specialists, and psychology researchers).

**202**

**PI:** Danilo Pozzo  
**Institution:** University of Washington  
**Project Title:** A Consolidated Chemical Engineering Laboratory with a Focus on Bioenergy  
**Project Number:** 0942590  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The primary goal of this project was to enhance student learning in the Chemical Engineering laboratory by providing a realistic experience of working as part of large organization/process in industry. We expect students to be more engaged in the course and prepared for their future careers.

**Methods & Strategies:** Using the themes of biotechnology and renewable energy, we have developed a new pedagogical model, which emphasizes 1) collaboration between teams and 2) developing instincts for thinking about the impact of single unit operations in the operation of an entire production facility.

**Evaluation Methods & Results:** Evaluations were performed by pre and post-course surveys comparing with a standard laboratory course (which they all take).

Some key survey results:

- The new laboratory structure and them offered a more useful learning experience. Survey Results: 81% of students agree or strongly agree.
- Compared to previous lab courses I have taken, the new laboratory structure is more relevant to the work done by real chemical engineers. Survey Results: 74% agree or strongly agree.
- The new course is taken by all chemical engineering seniors (~60 students/yr).

**Dissemination:** We have presented results in oral papers and posters presented at national conferences such as the ASEE and the AIChE. We are also expecting to submit the results of the exploratory project for publication this summer. The PI has also
travelled and discussed approaches with faculty from local universities.

**Impact:** The new course was well received by both faculty and students. The new strategy has been permanently adopted into the course and the department of Chemical Engineering has committed resources to continue supporting this initiative. There are also discussions about extending the learning model to the other two laboratories. Informal feedback from students that have graduated demonstrated that the new skills learned in the laboratory have helped them substantially in their new careers. The course was also very well received by alumni in local industry who have provided concrete support.

**Challenges:** Writing all new laboratory modules and getting equipment ready for students in a very short time for implementing the course was unexpectedly difficult. Fortunately, the department provided help by funding extra staff and personnel. We also noted that the new course is much more demanding with student time than previous laboratories. However, students still engage very well and appreciate the more realistic experience. They understand that these are important skills that prepare them better for entering the workforce.

**203**

**PI:** Michael Prince  
**Institution:** Bucknell University  
**Project Title:** Collaborative Research: Inquiry-Based Activities to Repair Persistent Student Misconceptions of Critical Engineering Concepts  
**Project Number:** 0717536  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The project seeks to bosh assess student misconceptions in the thermal sciences and develop and test activities for repairing those misconceptions. The project developed activities found to increase student learning 4 fold. We also developed concept inventories to conduct the assessment.

**Methods & Strategies:** Really described reasonably well above. This is primarily a quantitative study using a standard pre/post, quasi-experimental design. We have developed and tested a number of inquiry-based activities to address common misconceptions in heat transfer and thermodynamics.

**Evaluation Methods & Results:** Our primary results draw from pre/post concept inventory scores in both thermodynamics and heat transfer courses, both with and without the use of our activities. The results are significant - normalized gains are increased by a factor of 4 and the effect size is on the order of 1.8.

**Dissemination:** We have published and presented widely. I’ve also disseminated the results through teaching workshops to a number of national audiences.

**Impact:** Student learning has been increased dramatically. The work also interests faculty at workshops, although we have not yet prioritized efforts to disseminate the materials nationally.

**Challenges:** We find that faculty are still hesitant to use new materials because of concerns of time.

**204**

**PI:** Stella Quinones  
**Institution:** The University of Texas at El Paso  
**Project Title:** A Novel Applied Quantum Mechanics Course for Electrical Engineers  
**Project Number:** 094297  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:**
1. Improve the cognitive understanding of fundamental quantum mechanics concepts.
2. Improve the affective behavior of students associated with the learning experience of quantum mechanics and motivate them to take senior level Fields and Devices courses.
3. Increase the success, retention and graduation rates of ECE undergraduate students.
4. Increase the number and diversity of students enrolling in Fields and Devices concentration courses, especially female ECE students.

**Methods & Strategies:**
- Active learning
- One-minute essays
- Simulations and visual aids
- Alignment of course material with electrical engineering curriculum
- Peer leaders
- Workshops
- Concept maps
- Course webpage

**Evaluation Methods & Results:**
- Focus Groups
- Modified Self-Assessed Learning Gains
- How I Work Inventory
- Work Preference Inventory
- Performance Commitment Pathway
- Design of course was well received by students and designed at an appropriate level for most students

Impact: 1) Students that were enrolled in the course have gone on to apply to the Summer Undergraduate Research Fellowship at Purdue University; 2) Undergraduate students have been accepted as Ph.D. students at Purdue; 3) At least 2 students who took the course the first semester were hired by TI upon graduation; and 4) The course was adopted by the department in 2010, and approved as a required course in 2011. The course website will be actively disseminated to other universities at the end of Spring 2012.

Challenges: The development of the course website took much longer that anticipated and therefore the dissemination of the course is occurring later than expected.

205
PI: Ravi Ramachandran
Institution: Rowan University
Project Title: Collaborative Research: TUES: Vertical Integration of Concepts and Laboratory Experiences in Biometrics Across the Four Year Electrical and Computer Engineering Curriculum
Project Number: 1122296
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: 1) Develop a multi-year curricular material that allows biometric content in separate classes to be naturally inter-connected; 2) Achieve national dissemination of the material; 3) Obtain an in-depth evaluation of all proposed activities; and 4) Introduce biometrics at the high school level.

Methods & Strategies: 1) Achieve widespread adoption of vertical integration through project-based learning; 2) Use assessment tools and a statistical analysis to evaluate STEM learning, interest in biometrics and vertical integration across four schools; 3) Exposure to five biometric systems; and 4) Configure a TUES website.

Evaluation Methods & Results: Evaluation of STEM learning, perception of vertical integration, interest in biometrics, knowledge of biometrics, and concept inventory. 1) Pre and Post Assessment Test is implemented at the beginning and end of every course; 2) Rubrics used to quantify student achievement of program instructional outcomes; and 3) Pre and post-surveys with target/control group administered for each project followed by a statistical analysis.

Results: For a voice and face biometrics project, a statistical analysis showed enhanced STEM learning, knowledge and interest in biometrics and perception of vertical integration.

Dissemination: 1) Three conference publications, journal papers to follow; 2) TUES website configured - Java applets pending; and 3) The website’s content will be replicated on the NSF-sponsored Connexions website (http://cnx.org/) and cataloged within the National Science Digital Library, http://nsdl.org.

Impact: 1) Student impact of the voice and face biometrics project - a statistical analysis showed enhanced STEM learning, knowledge and interest in biometrics and perception of vertical integration; 2) Expected that more high school students will choose a STEM field; 3) Expected that more community college students will transfer to a 4-year university in a STEM field; and 4) Expected that the workshop will result in more faculty being interested in biometrics and vertical integration.

Challenges: 1) High school and community colleges do not have the same facilities to run the modules. All MATLAB based software experiments will be converted to EXCEL; 2) The math background of high school students has to be taken into account to configure the high school module; 3) The board of education at the high school needs to be convinced that the module is beneficial. For this to happen, a meeting with the board and the high school principal was set up; and 4) Faculty at the three universities are working very well together to implement the projects and the curricular innovations.

206
PI: Teri Reed-Rhoads
Institution: Purdue University - West Lafayette
Project Title: ciHUB.org, A Virtual Community to Support Research, Development, and Dissemination of Concept Inventories
Project Number: 0920589
Type: Phase 3/Type 3 - Comprehensive
Focus: Assessing Student Achievement

Goals & Intended Outcomes: The goals and intended outcomes of our project are one, to leverage a unique HUBzero cyberinfrastructure to migrate existing concept inventories to a single accessible location and support a collaborative community of faculty and students who use concept inventories; two, engage and equip a growing community of engineering faculty to be active users of concept inventories in targeted fundamental engineering courses; and three, conduct research to guide concept inventory refinement and community implementation.

Methods & Strategies: The strategies related to the three goals are to: 1) Implement a ciHUB.org and develop an organic, virtual community that is flexible to address the evolving needs of individual members and the community; 2) to provide faculty development opportunities to inform and instruct faculty users and developers and to market the ciHUB.org through popular media outlets and build community communication; and 3) develop and apply diagnostic model testing and calibration.
approaches to determine the feasibility of 'on-the-fly' cognitive skill diagnosis and investigate relationships between performance on concept inventories and scores on other instruments for various populations of interest.

**Evaluation Methods & Results:** To evaluate the research, we have an external evaluator and have established two Advisory Boards which receive annual reports and meet face-to-face annually; the CI Developers Advisory Board and the National Review and Evaluation (NRE) Board which is composed of experts in assessment, CI development, CI use, dissemination and HUB development and marketing.

In addition, user feedback within the ciHUB is gathered through periodic electronic surveying and tracking of questions submitted by users of the virtual community. Surveying of all workshop participants and annual meeting attendees provides the formative feedback we will utilize to continuously improve these efforts.

Summatively, the project will be judged based on impact as measured by faculty participation, student participation, and momentum of the overall CI community. Some of the proposed measurable outcomes include Google page ranks, Google trends for searches, social/organizational network analysis, number and variety of venues of faculty workshops, number of students taking CIs, number of distinct faculty using ciHUB in various roles, etc.

**Dissemination:** The ciHUB.org infrastructure itself functions as a dissemination mechanism that will also create new potential capabilities in community building by allowing registered visitors to not only utilize the concept inventories themselves, but to also view and create their own seminars, tutorials, podcasts, animations, publications, and simulations tools related to concept inventory subjects.

For a different type of dissemination through marketing, the ciHUB project will advertise its capabilities and availability through multiple facets such as Prism ads and working with professional societies through the Developer’s Advisory Board since they are funded to do concept inventory specific presentations and faculty development at the engineering professional societies associated with their specific discipline. This broadens the discussion from typical venues such as ASEE and FIE to ASME, AICHE, and IEEE, for example. One additional potential dissemination avenue will be the textbook publishers whom we will encourage to link promotional materials to ciHUB.

The project is developing a spectrum of faculty development initiatives to address faculty members at various stages. These initiatives include beginning with shorter time required experiences such as research briefs, to longer experiences such as research papers, to a more interactive stage of workshop participation. These efforts will target both users of concept inventories and developers of concept inventories. In addition, annual meetings serve as face-to-face complementary meetings to the virtual community being developed through the HUB Zero infrastructure.

**Impact:** Concept inventories represent a relatively unique form of an assessment instrument with a multitude of possible uses that range from diagnostic and formative purposes to guide instructional planning, to summative purposes for evaluating overall learning and instructional effects at a student, classroom, and/or instructional program level. The ciHUB will be key to growing a sustainable community of researchers, educators, and students who develop or use concept inventories for continuous improvement of conceptual understanding and to significantly clarify the link between teaching techniques and conceptual understanding. The ciHUB will enable first-time connections in studying entire undergraduate engineering curricula with commensurate growth in understanding how conceptual understanding of various fundamental subjects evolves and interconnects during four-year programs. This new community of scholars will enable exemplary teaching and in turn will generate a new cycle of innovation for transforming engineering education.

**Challenges:** Most challenges experienced by this project have been associated with interest and demand while trying to work on improving accessibility, associate information, and development. Measurement of learning gains is continuing to be a highly sought after assessment method and concept inventories are considered one of the most valid and reliable mechanisms for such efforts.

**207**
**PI:** Kenneth Reid
**Institution:** Ohio Northern University
**Project Title:** Classification of First Year Engineering Courses Based on Descriptions, Outcomes and Assessment
**Project Number:** 1042030
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** This proposal intends to establish a classification scheme for first-year engineering courses, synthesize and disseminate broadly existing assessment strategies, and identify the assessment gaps.

**Methods & Strategies:** An Imen-Delphi procedure is used to survey participants in multiple rounds toward building consensus on a classification scheme. A workshop will be held to coincide with a major conference in which the participants will finalize results.

**Evaluation Methods & Results:** The initial items for the first round of the Delphi study are complete; a list of individuals involved in first-year engineering is also ready. Invitations to participate will be issued via email and at summer conferences.
Participants will engage in the Delphi study through the academic year, then selected participants will be invited to finalize the classification scheme and list of assessment gaps in the final workshop.

**Dissemination:** An initial Work-In-Progress paper has been submitted to Frontiers in Education, and an abstract will be submitted to the First-Year Engineering Education conference. Papers will be developed and presented at ASEE and IEEE until a final paper is developed for an Engineering Education Journal.

**Impact:** The anticipated impact is to allow universities, community colleges, funding agencies, etc. to use the developed classification scheme as developed to accurately determine credit awarded for transfers, to develop introductory engineering coursework, and to identify and fund efforts toward appropriate assessment gaps.

**Challenges:** The lead institution is an undergraduate-only institution, thereby limiting the available time of the investigators. A unique opportunity to overcome this difficulty came in the newly-approved Bachelor of Science in Engineering Education degree, allowing undergraduate students with an interest in engineering education research to assist. This has been extremely beneficial.

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**208**

**PI:** Carolyn Rose  
**Institution:** Carnegie Mellon University  
**Project Title:** Collaborative Research: Networked Collaboration Modules for Integrating Mathematics and Engineering Education Using Intelligent Agents  
**Project Number:** 1022958  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** 1) Offering a dynamic self-paced learning environment for student use outside of traditional classroom lectures; 2) a machine-monitored internet chat-based tutorial environment that has no geographic constraints, and offers an excellent means for long-distance collaborative learning; and 3) fundamental studies of effective means for student learning.

**Methods & Strategies:** The approach of this project consists of two pillars: 1) self-paced web tutorials guiding students through software use; and 2) dynamic, dialogue-based tutorial interfaces which engage students in interpreting simulation results they create.

**Evaluation Methods & Results:** Evaluations are conducted as large scale classroom studies and online collaborative learning studies conducted in distance education mode. We have focused so far on a bending stress lab. Students learned effectively in this online agent guided lab. We are still analyzing the data from the most recent study.

**Dissemination:** We have a wrench design lab and a bending stress analysis lab which are both ready to disseminate on a large scale. So far we have run studies in distance mode with Drexel and UCSB.

**Impact:** This project provided the opportunity to mentor two Ph.D. students who were very involved in all aspects of the work, including design of educational materials, software development, designing and running classroom studies, analyzing data, and writing research publications.

**Challenges:** None so far.

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**209**

**PI:** Benjamin Ruddell  
**Institution:** Arizona State University  
**Project Title:** Collaborative Research: Cyber Enabled Data and Modeling Driven Curriculum Modules for Hydrology Education  
**Project Number:** 1043996  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** Arizona State University, in collaboration with SERC, Purdue, and the Chandler-Gilbert Community College, aim to develop and validate an prototype cyberinfrastructure utilized for publishing and then utilizing data and modeling driven geoscience cybereducation curriculum materials in the UG classroom.

**Methods & Strategies:** This project is building a prototype CI that leverages the SERC/NSDL curriculum dissemination and discovery system, expanding its capabilities to handle data and modeling curriculum materials that are published in a modular and quality-controlled fashion. It will be tested in the UG classroom.

**Evaluation Methods & Results:** Each data and modeling driven geoscience cybereducation curriculum module has a pre and post outcomes assessment built in. The modules will be deployed in the undergraduate (UG) engineering and geoscience hydrology classroom in parallel with traditional lecture materials, and evaluated against the control group for achievement of hydrology learning outcomes. Modeling and data outcomes will also be assessed. In addition, we are holding peer review workshops, both formal and informal, for UG hydrology educators to assess the CI structure and usability.

**Dissemination:** Materials will be directly disseminated through SERC/NSDL, and in partnership with hydrology community organizations such as MOCHA and CUAHSI.

**Impact:** We anticipate that this CI will open the door for the publication of community-based and community-authored data.
and modeling driven geoscience cybereducation curriculum materials, and that this new capability will improve overall geoscience education outcomes, especially in the USA and in the hydrology engineering and geoscience communities in the undergraduate classroom.

**Challenges:** Not unexpectedly, it is difficult to complete classroom assessment of curriculum materials, due to logistical and scheduling issues.

**210**

**PI:** Maryam Saeedifard  
**Institution:** Purdue University  
**Project Title:** Collaborative Research: Development of a New Power Electronics Curriculum Relevant to Tomorrow’s Power Engineering Challenges  
**Project Number:** 1044338  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** This collaborative proposal aims at integrating concepts of modern renewable energy conversion and electric transportation into the undergraduate power electronics and machines electrical engineering curricula at Purdue University and Iowa State University. This is achieved by (i) modifying course syllabi, and (ii) upgrading our laboratory facilities.

**Methods & Strategies:** Our pedagogical strategy is based on (i) inclusion of research-based sequential assignments and collaborative design projects, and (ii) step-by-step design, implementation, and digital control of a set of power electronic circuits in the laboratory based on the concept of rapid prototyping. This is achieved by using a Digital-Signal Processor (DSP) board in combination with MATLAB/Simulink real-time tools.

**Evaluation Methods & Results:** Prof. Cordelia Brown from Purdue University acts as the external evaluator. Three different types of assessment, i.e., pre-assessment, formative assessment, and summative assessment are involved as (i) a survey-based pre-assessment conducted during the first lecture of the PIs’ classes to understand the students’ background and expectations; (ii) a small group analysis conducted during the semester; (iii) a small group analysis and a post-assessment questionnaire conducted at the end of the semester; (iv) the collective institution-wide course and instructor evaluations administered at the end of the Semester; (v) the students’ learning experience and the instructional approach in the new laboratory monitored based on pre-laboratory assignments and in-laboratory performance.

**Dissemination:** So far, all educational material developed by this effort (such as detailed instructions for setting up the laboratory and conducting the experiments) has been made freely available, posted on the course web page at Purdue. The PIs will further disseminate the results through conference presentations and/or a journal publication.

**Impact:** The observed and anticipated impacts are: (i) increased involvement of the students from the underrepresented groups, specifically female students at Purdue (ii) Attraction of undergraduate electrical engineering students into a power systems track.

**211**

**PI:** Jafar Saniie  
**Institution:** Illinois Institute of Technology  
**Project Title:** Remote Environments for Undergraduate Computer Engineering Laboratories  
**Project Number:** 0942179  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The key objective of this work is to provide remote access capability for undergraduate computer engineering laboratories and to create cyber-enabled laboratory environments.

**Methods & Strategies:** The development phase for transforming laboratories includes custom hardware interfaces for laboratory test equipment, audio/video interaction, desktop sharing and real-time supervision by lab instructors.

**Evaluation Methods & Results:** This study will assess the feasibility of the proposed cyber-enabled laboratories by analyzing a comparative study of remote students and local students using a comprehensive assessment plan (monitored and examined by an external evaluator). The outcome of this investigation will show the pitfalls and associated remedies for implementing remote laboratory experiments and it can be used as a working model for other institutions.

**Dissemination:** We are committed to sharing our experience through publications and education oriented conferences with other institutions in order to accelerate the adoption rate of cyber enabled computer engineering laboratories in the higher education institutions.

**Impact:** Remote laboratories will help to attract a larger, more diverse undergraduate student body in computer engineering program by removing the geographical limitations. The outcome of this investigation will show the pitfalls and associated
remedies for implementing remote laboratory experiments and it can be used as a working model for other institutions.

**Challenges:** We encountered the following challenges: 1) Complex hardware interface development is required for certain experiments. These experiments are revised to conform and make it feasible for cyber enabled framework; and 2) Experimental trials suggest that there is a change in social dynamic that students work in when conducting experiments in a laboratory. A carefully designed social component is needed to create a successful team based learning experience in the laboratory for remote students.

212

**PI:** Lisa Schneider  
**Institution:** Cornell University  
**Project Title:** Applications and Confidence Inventories for Assessing Curricular Change in Introductory Engineering Mathematics Instruction  
**Project Number:** 0837757  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** This project develops two assessment instruments to gauge students' abilities in using mathematics in engineering contexts and students' self-efficacy perceptions related to studying engineering and to applying mathematics. The instruments may be used to assess the effects of integrating applied science and engineering problem-solving into engineering mathematics courses.

**Methods & Strategies:** The Mathematics Applications Inventory (MAI) was developed with extensive input from engineering and mathematics faculty. Administration of a long-answer version followed by respondent interviews informed development into a multiple-choice inventory. The Engineering and Mathematics Perceptions Survey (EMPS) was adapted from an existing instrument and has undergone reliability and validity testing. Both instruments have been administered to large samples of first-year engineering students at our university.

**Evaluation Methods & Results:** The MAI and EMPS instruments were administered in Fall 2010 to all students in the first-semester engineering mathematics course (N=379), which includes an applied problem-solving workshop innovation; and to all students in the second course in the engineering mathematics sequence (N=441), which does not include the workshop innovation. In addition to validity and reliability testing, analyses include comparisons of responses and pre- to post- performance by course, associations between EMPS responses and MAI performance, common areas of difficulty related to the application of specific mathematical content areas and cognitive domains, and patterns of responses by background and status variables such as gender, race, SAT scores, and level of mathematics preparation.

To reduce the influence of nonequivalence between treatment and control groups, differences in gains were tested with the use of a propensity-score-based stratification strategy. Data analysis methods include: 1) observation of score distributions & gains by course, pre- to post-, for MAI multiple-choice (MC) & open-ended (OE) versions, and for self-efficacy (SE) subscale scores; 2) bivariate regression analyses to estimate effects on MAI performance, pretest, posttest, and gain; 3) GLM regression analysis to estimate effects on MAI gain. We test the hypothesis that differences in gains could be attributed to differences in math course experiences (i.e., treatment effect of participation in workshops).

Findings reveal significant differences in student performance on applied problem-solving by gender, and suggest that the workshop intervention helps to alleviate these differences.

**Dissemination:** Two papers were presented and published in the ASEE 2010 annual conference proceedings: 1) an overview and progress report on the project; and 2) an in-depth report on the process of developing the Mathematics Applications Inventory. Another paper on project results was presented and published in the ASEE 2011 annual conference proceedings. Further efforts to present and publish the subsequent findings following more in-depth analyses of differences in MAI performance by gender and by content area and cognitive domain of MAI items are ongoing. We also aim to encourage use of the MAI at other institutions.

**Impact:** Findings have been used to help assess the effect that integrating collaborative, applied, problem-solving workshops into the first-semester engineering mathematics course has on students’ abilities and attitudes about using mathematics. The positive impact of the workshops on the performance of female students, in particular, has helped support the decision to continue the workshop innovation. It is also our intention to promote the use of the MAI for the assessment of related innovations in engineering and mathematics instruction at other institutions. Further, we have shared the project as a model for the assessment of student learning outcomes and the evaluation of curriculum innovations at our institution.

**Challenges:** Expanding our project focus to include an assessment of the impact of a switch from small-section to large-section instruction for first-year calculus resulted in the involvement of more courses and more instructors than were initially involved at project conception. We did encounter the challenge of ensuring full cooperation with data collection efforts within all courses. This affected the response rate on our post-test MAI administration in one of our target courses, which then limited the power of our analyses for that aspect of the project.
213

PI: Roger Seals
Institution: Louisiana State University
Project Title: Strengthening the Competitiveness of Engineering and Computer Science Faculty
Project Number: 1151808
Type: Central Resource Project
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: To improve the proposal writing and project management skills of faculty and to improve the quality and quantity of TUES proposals submitted by Engineering and Computer Science faculty.


Evaluation Methods & Results: On-line surveys of workshop participants and facilitators using Likert-scale and open-ended questions. Participants perceive that the stated individual workshop outcomes have been achieved to a high degree.

Dissemination: Dissemination is via the workshops themselves. Invitations are sent to all engineering colleges and computer science departments to participate.

Impact: Unfortunately, the actual impact of the project with respect to its overall goals is unclear. That is, we have not determined if, as a result of the webinar series, the quality of the proposals submitted by the workshop participants is higher and the number is greater. We do know that we have introduced the TUES Program to a significant number of faculty who had never submitted a proposal to the Program.

Challenges: It’s a challenge to get college and departmental administrators to actually understand the value of the workshops and take the initiative to host the sessions at their institution. Another logistical challenge is the failure of some institutions to provide the verbal link between their participants and the workshop presenters.

215

PI: Youngwoo Seo
Institution: University of Toledo
Project Title: Water Distribution System Analysis Lab Modules and Kits for Undergraduate Education
Project Number: 1044823
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The main objective of this project is to develop and test water distribution system analysis lab modules and kits, which allow students to understand the physical, chemical and biological dynamics in water distributions.

Methods & Strategies: Seven function-adaptable modules (4 basic and 3 integrated modules) and kits will be developed and tested at participating universities.

Evaluation Methods & Results: Lab modules and kits were evaluated with TAs' feedback, instructors' feedback and the course evaluation forms at participating institutions. These provided general feedback as to the effectiveness and academic value of the modules and kits. A detailed analysis and specific
evaluation of each component in the modules and kits were also completed via detailed student surveys as well as instructor’s assessments.

**Dissemination:** After testing, evaluating and modifying both basic and integrated laboratory modules and kits at the UT and the UD, the WDSAL labs and kits will be disseminated to three participating universities.

**Impact:** Project expects to: 1) increase students' understanding of water distribution networks by providing systematic information and concepts; and 2) improve the current civil engineering curriculum by developing and providing hands on lab based modules and kits related to fluid mechanics, hydraulics, water chemistry and microbiology for integrated student understanding.

**Challenges:**
1. Communication with participating instructors-> persistently sending out emails
2. Managing class schedules (incorporating new information without loosing pre-existing course material)

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**216**

**PI:** Mehdi Setareh  
**Institution:** Virginia Tech  
**Project Title:** Integrating Web-Based Visualization with Structural Systems Understanding to Improve the Technical Education of Architects  
**Project Number:** 0817106  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** This project develops a web-based visualization system to improve the understanding of architecture students and architects on inter-relationships between structure and form, called Structure and Form Analysis System (SAFAS). The outcome is web-based modules that students from anywhere in the U.S. or around the world can access and use the interactive modules for better understanding of structural engineering fundamentals through the use of spatial structures.

**Methods & Strategies:** This project has been developed through a collaborative effort between faculty and students from different departments at Virginia Tech and two other institutions. The main strategy used for this project was to develop the educational materials for on-line use in order to facilitate their dissemination. To maximize their impact for technical education of architects, numerous images and video-clips are included in addition to software which allows students to learn about behavior of spatial structures under loads using an experiential approach.

**Evaluation Methods & Results:** We planned both formative and summative evaluations for the project outcome in our proposal. We have completed the formative evaluations, and are currently conducting the summative evaluation of the project. All the evaluations have been conducted using on-line forms. The students were given a pre-test to evaluate their knowledge of the subject matters prior to the use of SAFAS. Subsequently, they were given two sets of three assignments to complete, which were graded and compared to the results of the pre-test. This showed significant improvement of students' knowledge about the structural behavior of spatial structures.

**Dissemination:** The main dissemination venue is the project website. SAFAS have been used by the students at Virginia Tech, University of Illinois, and Hampton University. In addition, we have published several peer-reviewed papers in conference proceedings along with one journal paper currently under review for publication and two other journal articles in preparation. Our future plan for dissemination includes the use of SAFAS at Virginia Tech, and University of Illinois. Other schools have also shown interest in adopting our developed educational materials.

**Impact:** The direct impact of this project has been on better understanding of structural behavior by architecture students at our school and the other two participating institutions. As of today, over one hundred students have used SAFAS. In addition, we have established the Center for Advanced Visual Media at the College of Architecture and Urban Studies of Virginia Tech. We have used the project funds to procure a large stereoscopic computer display, which is being used by architecture students for learning about the various aspects of SAFAS in an immersive virtual environment.

**Challenges:** The main challenge has been with the development of the second module of the SAFAS as related to the identification of the problems and errors in the software. Even though this was time-consuming, it was not unexpected.

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**217**

**PI:** David Shaffer  
**Institution:** University of Wisconsin-Madison  
**Project Title:** Professional Practice Simulations for Engaging, Education and Assessing Undergraduate Engineers  
**Project Number:** 0919347  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** This Phase 2 CCLI proposal seeks to develop, implement, and assess a computer simulation game for engineering undergraduates, modeled on authentic engineering practices, to increase the persistence of women in engineering majors.

**Methods & Strategies:** We have developed and implemented the simulation at two universities. The simulation is a
customizable web based platform in which students design a kidney dialysis membrane. The simulation is implemented in first-year engineering courses.

**Evaluation Methods & Results:** We collect survey data on students’ attitudes about engineering at the beginning and end of the course, both from students who experience the simulation (treatment group) and from students who do not (control group). Our results to date show that women in the treatment group (that is, who use the simulation) have a more positive attitude towards engineering than those in the control group.

**Dissemination:** We have disseminated the simulation to a second university, and are planning to make it available to other schools of engineering.

**Impact:** It is beyond the scope of the current project to measure longitudinal impact on completion of degrees in engineering. However, we have applied for additional funding to do so.

**Challenges:** We did not encounter any unexpected challenges.

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**218**

**PI:** Sheri Sheppard  
**Institution:** Stanford University  
**Project Title:** Collaborative Research: Engineering Pathways Study--The College-Career Transition Informing Educational Practice  
**Project Number:** 1022644  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** This study aims to better understand the career experiences and decisions of engineering graduates, their first few years out of school. The work goes to explore how these experiences/decisions are tied to particular educational experiences.

**Methods & Strategies:** Interviews of engineering graduates, four years post-graduation informed the design of a survey deployed to almost 500 alumni in the all of 2011. The survey includes items about educational experiences, as well as work place details. Preliminary analysis of survey data is revealing that nearly 20% of graduates are not doing engineering work, yet express that their engineering background is informing their work. Additional survey analysis (coupled with interview analysis) will reveal more details about this, and other career/ work situations.

**Evaluation Methods & Results:** Our evaluation strategy is to assess the extent to which this project (EPS) continues to build on research strategies and data from its predecessor project, the Academic Pathways Study (APS). Connected together, our data give us a glimpse into the identity, confidence and knowledge development of individuals interested in engineering over an eight year period—from the time they matriculate college to four years post graduation. This is a unique look at how students experience their education, and how their education continues to inform their professional engagement.

**Dissemination:** Dissemination is through conference papers and presentation (e.g., ASEE 2012) and journal papers. There are two PhD theses being written based on these data. In addition, individual school reports are being compiled for each of the four schools involved, as a means of making the findings accessible to mainstream engineering faculty and administrators.

**Impact:** In addition to research papers, findings are being compiled into formats that are easily accessible to faculty, administrators and students. The goal is to stimulate faculty, administrator and student discussions as part of informing/ affecting educational practice; in particular discussions (if not debates) around educational practices that seem to support application of educational learnings in work practice.

**Challenges:** It was harder to get alumni to complete the survey than it was with students. We would rethink our survey incentive structure in the next deployment of the survey.

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**219**

**PI:** Enid Sichel  
**Institution:** Five Colleges, Inc., Amherst MA  
**Project Title:** Authoring Tool for a Hands-on, On-line, Lab Curriculum for Engineering Technology Students  
**Project Number:** 1143659  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Increase students' learning in circuit analysis; enhance students' ability to use scientific and quantitative reasoning; and drive innovation in teaching engineering and physics.

**Methods & Strategies:** Interactive lab manual for hands-on experiments provides immediate feedback (grading) of the laboratory report and an opportunity for students to correct their errors.

**Evaluation Methods & Results:** Created pre-lab and post-lab brief questionnaire on-line to assess student knowledge of the topic covered in each lab. Questionnaires have been coded and embedded in the lab software. We use concept questions, rather than computational questions.
Dissemination: We have spoken and/or corresponded with professors at more than 4 community colleges, 5 maritime academies, and 5 other colleges and universities.

Impact: The first deployment of our software was at three laboratories at a technical community college. We were pleased that the students were engaged and cooperative. The participating professor has indicated willingness to participate in the next semester.

Challenges: Budget difficulties because of the recession have caused one of our participants to turn over their electronics technology curriculum to a telecommunications company in need of skilled workers. The telecommunications company is funding the classes. We cannot participate. One of the recruited maritime academies has abandoned hands-on labs due to lack of funding for equipment and substituted simulation software. We have redoubled our efforts with other colleges.

220
Pi: Judith Sims-Knight
Institution: UMASS Dartmouth
Project Title: Can Students Use Assessment-based Double-loop Learning to Improve their Design Skills?
Project Number: 0941233
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The first objective of this project was to validate three assessments of design process knowledge and skill developed in a previous NSF grant as tools for curricular development. The second objective was to teach students to use assessment to improve their ability to create open-ended designs.

Methods & Strategies: The first objective was executed by giving the three assessments to all students in Electrical and Computer Engineering. For the second objective assessments of design process skill were given after each of three design projects. Students used the results to write continuous improvement plans.

Evaluation Methods & Results: In Phase 1, we analyzed student performance across the four years of the curriculum with ANOVA. We found that seniors outperformed freshmen in all assessments, but there was room for improvement at all levels and in most phases of design. As predicted, performance was better on declarative knowledge than on using that knowledge. Reports based on the results were effective in fostering discussions of curricular improvement. Phase 2 will be evaluated by whether students improve in (a) their designs, (b) their use of effective design process, and (c) their continuous improvement plans.

Dissemination: In addition to journal articles, conference papers, and a website, we will create a webinar of the sort that can be accessed and used at the users’ convenience. Its objective will be to help faculty develop strategies to promote students’ development of skills through continuous improvement.

Impact: The anticipated impact of the program is to provide a scientific basis for promoting improved instruction in design process in engineering disciplines in two distinct ways. One is to support curriculum-wide change by providing effective assessments for continuous curricular change. The second is to support course-based improvement in design process learning through assessment-based continuous improvement by students.

Challenges: Our only major problem was that the start date of the grant was delayed several months, so that we were unable to counterbalance order of simulation assessments. We had intended to give half the students simulation A at the beginning of the semester and simulation B at the end of the semester and to reverse the order for the other half. We were forced to give one simulation at the beginning of the semester because we could only prepare one.

221
Pi: Brian Skromme
Institution: Arizona State University
Project Title: Problem Generation, Solution, Student Input, and Tutoring Modules for Introductory Linear Circuit Analysis
Project Number: 1044497
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goals of the project are to develop & disseminate novel cyberlearning instructional materials for undergraduate electrical engineering courses on introductory linear circuit analysis, and to integrate the above software elements into a prototype interactive tutoring program.

Methods & Strategies: Our software will be able to automatically generate linear circuit problems for students to solve, along with fully worked example solutions. It will also accept and evaluate student input in the form of equations, numbers, re-drawn circuit diagrams, and waveform sketches.

Evaluation Methods & Results: Learning objectives are being developed for each of the topics to be taught. Student progress towards these objectives will be monitored using embedded assessment in the tutoring system, evaluated by an experienced independent evaluator supported by the grant. Data from control sections not using the tutorials will be collected using similar algorithmic exercises through an online grading system. Quantitative data will be collected on drop rates, relevant exam and homework scores, and concept inventories in both control & experimental sections.
Dissemination: We are presenting an ASEE conference paper this June. Additional dissemination will be through conferences, journal publications, and seminars, as well as open source distribution and/or commercial distribution through a textbook publisher’s system (e.g., WileyPlus).

Impact: We are involving various other faculty at ASU who teach this course as well as instructors at several other universities & community colleges who have committed to use the materials. Commercial distribution of the materials (already tentatively supported by Wiley) will achieve wide, sustained dissemination. We expect to impact at least 250-300 students during the initial two-year project. We aim to achieve learning gains of at least 0.5-1.0 standard deviations and satisfaction ratings of at least 4.0/5.0. We plan to use the materials continuously after the project ends.

Challenges: Our major challenge has been in integrating and merging the efforts of several software developers working in parallel. We have addressed this issue using regular communication meetings as well as more frequent merges of the work.

222
Pt: Joseph Slater
Institution: Wright State University
Project Title: Enhancing Integrated Technology and Interdisciplinary Based Engineering Education Through the High Altitude Balloon (HAB) Experience
Project Number: 0837677
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: Through working on this project, students delve into a complex multidisciplinary engineering system that requires working across all engineering disciplines and involves them in methods of applied technology and skills necessary to transition from academic to professional environments.

Methods & Strategies: The projects themselves are chosen in such a way that leveraging the expertise of students in other majors is necessary. Failures of projects tend to be harsh when expertise is not utilized. A very significant history of documentation motivates students to utilize vast knowledge and resources.

Evaluation Methods & Results: We have you perform the evaluation. We will be generating a survey to give employers to assess the performance of our students compared to their peers (control).

Dissemination: Multiple conference papers have been presented. Notably multiple presentations have been given by students at professional level conferences that faculty/researchers attend. Their performance in professional settings as sophomore-seniors has greatly raised awareness of the successfulness of our approach.

Impact: Multiple programs in the college have already agreed to move toward a common senior design sequence to encourage, rather than discourage, multidisciplinary design projects. An experiential learning track (12 hour certificate) will be added shortly to provide a more formal recognition of this learning process on student transcripts through a coordinated curricular plan. This certificate will incorporate significant peer-mentoring as part of the curricular responsibility. Finally, an entire new degree program is being generated based on positive feedback from local employers.

Challenges: The principle challenge is incorporating this material into a wide variety of classes. Getting wide faculty buy-in is nearly impossible when significant effort (change) is required of individual faculty without them receiving personal benefit. Instead we have bypassed standard courses, linking the project activities to courses already taken by the students. More senior students utilize junior students for analysis requiring earlier coursework, and as a result both benefit from the time savings and tutor the junior students. The vertical integration yields a sustainable educational model.

223
Pt: Gangbing Song
Institution: University of Houston
Project Title: Collaborative Research: Develop Innovative Labs-to-Go Kits for Multidisciplinary Undergraduate Engineering and Technology Education
Project Number: 0942552
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The general goal of this project is to develop a family of affordable take-home Labs-to-Go (LTG) kits suitable for multi-disciplinary undergraduate engineering and technology education. The intended outcomes include improved students’ learning experience in related courses.

Methods & Strategies: This project develops novel, low cost, portable, multifunctional Labs-to-Go (LTG) kits to enable take-home hands-on experiments that are suitable for multidisciplinary undergraduate engineering and technology education by using the available USB-based data acquisition and real time control as well as smart materials technologies.

Evaluation Methods & Results: A formative evaluation approach was used to evaluate project activities the project process. Project objectives were evaluated by assessing the project short-term outcomes and project long-term outcomes. A formative evaluation approach was used to evaluate project activities. The project’s short-term and long-term outcomes,
which align with the project’s short-term and long-term goals, were evaluated using the summative evaluation approach. Given the richness of qualitative and quantitative data, the project evaluator utilized a mixed methods approach to collecting and assessing the outcome data.

**Dissemination:** Through the integration with teaching activities, the results were directly disseminated to two different universities and the LTG technology benefited 300 (estimated) engineering and technology students. Research and educational results will be disseminated via other channels: 1) Conference and journal publications. 2) Websites at UH and UHD. 3) Lab tours and experimental demos to visitors.

**Impact:** The LTG kits enhanced student learning involving structures, dynamics, control, and electronics technology in education in multiple disciplines including civil engineering, mechanical engineering, and electronics technology. It benefitted not only research universities but also two-year and four-year universities/colleges.

**Challenges:** Though we were successful in developing labs to go kits for measurement, we have encountered difficulty in implementing real time feedback control using a low-cost control system. We are still working on this issue.

**224**

**PI:** Andreas Spanias  
**Institution:** Arizona State University  
**Project Title:** Collaborative Research: Phase 3 Design, Implementation and Dissemination of Multidisciplinary Online Java Digital Signal Processing (J-DSP) Materials  
**Project Number:** 0817596  
**Type:** Phase 3/Type 3 - Comprehensive  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Create new Java and mobile education technology by new functions for several disciplines including Earth Systems, Renewable Energy, Arts and Media, and Computer Science. Expand the existing signal processing users community and create new multidisciplinary user communities with student and faculty collaboration.

**Methods & Strategies:** Create and assess customized J-DSP content and software and disseminate through national workshops that (a) create new learning and user communities, and (b) train culturally and gender diverse groups of students and faculty. Assessment instruments are deployed and new customized assessment will be generated to evaluate all practices.

**Evaluation Methods & Results:** We have conducted assessments with graduate and undergraduate students on each of the modules developed. Each assessment usually consists of a pre-quiz, a hands-on exercise, a post-quiz and a user experience survey. The pre- and post-quizzes are used to evaluate the technical effectiveness of the modules, and the user experience interviews provide insight on future directions and other improvements to the software. Assessments have been carried out for JDSP (J-DSP on iPad/iPhone), J-DSP Earth systems edition, J-DSP for ion-channel sensors, audio, RF and communication systems. Details are available at http://jdsp.asu.edu.

**Dissemination:** We have conducted workshops in FIE 2009 and FIE 2010 conferences and GSA NE/SE meeting 2010. We have also conducted several workshops both at Arizona State University and internationally. Furthermore, we have published papers in ASEE (2009-2012), FIE (2009-2012), ICASSP 2012 conferences and several journal papers are in preparation. We plan to release the iPhone/iPad version of J-DSP to the Apple store. A book that illustrates DSP concepts using J-DSP software has been published. Details can be found at http://jdsp.asu.edu/

**Impact:** We estimate that the technology generated in this phase 3 program impacted more than 3000 students. Our software and labs have been disseminated to more than 50 universities. We have documented systematic use with assessment in at least five universities. The software has been adopted for a biomedical signal processing course at MIT.

**Challenges:** Extensions to interdisciplinary areas such as Earth systems required a lot of collaborative effort and infrastructure modifications to the program, apart from addition of new functions to suit the conventions used by geoscientists and their expectations. Porting the software to mobile platforms such as iOS and Android required redesign of the infrastructure code and visualization modules, in addition to rewriting many functions.

**225**

**PI:** Ruth Streveler  
**Institution:** Purdue University  
**Project Title:** Collaborative Research: Expanding and Sustaining Research Capacity in Engineering and Technology Education: Building on Successful Programs for Faculty and Graduate Students  
**Project Number:** 0817461  
**Type:** Phase 3/Type 3 - Comprehensive  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:**

Three project goals:

1. Design and deliver a new generation of programs to educate engineering and engineering technology faculty and graduate students to conduct and use educational research which are effective, flexible, inclusive, and sustainable after funding ends.
2. Foster a virtual community of engineering and engineering technology education researchers through the use of Purdue HUBzero technology.
3. Evaluate the impact of these programs on individuals who participate and on the participants' students and institutions.

**Methods & Strategies:**
Goal 1: Creating face-to-face workshops and short courses that help engineering faculty learn about educational research methods. We take the approach that faculty already know about quality research in their technical area - we ask faculty to compare and contrast research in technical areas with research on teaching and learning.

Goal 2: Create online educational materials (mainly video of face-to-face workshops) that is useful for a remote audience.

Goal 3: Impact is evaluated through short surveys (for short courses) and through observation, focus groups and follow-up interviews for multiple-day workshops.

**Evaluation Methods & Results:** Evaluation is accomplished through using the following methods.
1. Usage statistics - face-to-face attendance [for short courses and workshops] and Google Analytics for virtual community.
2. Pre- and post- knowledge surveys for short courses.
3. For multiple-day workshops - observation during the workshops, focus groups, interviews, analysis of products.

**Dissemination:** Dissemination through workshops at ASEE and FIE, online through CLEERhub. Publications and conference papers as continued and continuing dissemination. Continued dissemination through cyberinfrastructure (CLEERhub.org) which continues after funding for this project ends.

**Impact:** Usage statistics are our most immediate level of impact. About 200 people have participated in face-to-face activities. CLEERhub.org has about 5000 visitors to date. Pre- and post- knowledge surveys do show increase in knowledge by participants. Analysis is ongoing for longer-term impacts.

**Challenges:** Creating a cyberinfrastructure (Collaboratory for Engineering Education Research or CLEERhub.org) was a new venue for us. Method for dealing with this was including collaborators who were experts in online delivery and keeping an open mind.

**Project Number:** 0920500
**Type:** Phase 2/Type 2 - Expansion
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal is to reduce to practice the most abstract concepts of quantum mechanics by hands-on experiments. Outcomes are (1) increasing student knowledge and skills; (2) project website with near 3,500 visitors; (3) faculty training through ALPhA immersion program, publications and invited lectures.

**Methods & Strategies:**
1. Teaching the abstract concepts by hands-on experiments
2. Applying this method to DIVERSE educational institutions;
3. Feedback from the students and student involvement in the project;
4. Wide dissemination of the results and adaptation of the materials from the STEM educational knowledge base.

**Evaluation Methods & Results:** We used both formative and summative evaluation methods with the help of an external evaluator. Student participants were surveyed with respect to the content knowledge as well as their impressions about the activities and about science in general. 92% students indicated that they were more interested in this topic after the labs. Students demonstrated substantial gains between their pre-lab and their post-lab responses. During the 2011-2012 academic year we started to calculate individual item difficulties, discrimination and response pattern data for each assessment item.

**Dissemination:** (1) Maintenance of the project website http://www.optics.rochester.edu/workgroups/lukishova/QuantumOpticsLab/ linked with NSF supported www.thequantumexchange.com. (2) Faculty training through the ALPhA immersion program and invited lectures; (3) More than 13 publications.

**Impact:** A broad impact on STEM education is the new method of teaching one of the most difficult and weird concepts of modern physics (quantum mechanics). The project directly impacts a group of students and teachers with diverse backgrounds. Both university and two-year college students (with 50% women and 30% minorities) and professors are involved in this project. Starting from a Phase I project, a total of 210 students (49 groups) passed through the labs with lab report submission and more than 186 students (~16 groups) through lab demonstrations.

**Challenges:** The main challenge of the project is the lack of space in the undergraduate curriculum. We have adapted to this main challenge by developing a series of modular 3-hour experiments and 20-min-demonstrations that were incorporated into a number of courses ranging from freshman (OPT 101) to senior level, in both physics (PHY 243 W) and engineering (OPT 223). Rochester Monroe Community College
students also benefited from this facility by carrying out two 3-hour labs at the University of Rochester.

227
PI: Christopher Swan
Institution: Tufts University
Project Title: Engineering Faculty Engagement in Learning Through Service - EFELTS
Project Number: 1022927
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes:
Goal 1: Understand the motivations, obstacles, and strategies for engineering faculty who currently offer Learning Through Service (LTS) opportunities.
Goal 2: Increase the involvement of engineering faculty engaged in LTS.

Methods & Strategies: The proposed project will follow a 4D process. Discovery involves accruing knowledge via faculty surveys; Distill involves collecting information via interviews of LTS faculty; Design consists of convening a meeting of LTS experts; and Disseminate gathered information via faculty workshops.

Evaluation Methods & Results: The focus of evaluation is primarily on faculty with student views considered secondarily. The evaluation methods include a faculty survey that focuses on LTS efforts and a faculty interview protocol. In addition, artifacts will be captured from the LTS experts meeting as well as from subsequent workshops including meeting notes and created documents, workshop documentation, and post-workshop faculty outputs (i.e., their LTS efforts post-workshop).

Dissemination: To date, results from the experts meeting and survey responses have been developed into two conference papers in the upcoming ASEE annual conference. Future efforts focus on faculty interviews (to be completed soon) and the various faculty workshop outputs.

Impact: While the faculty workshops have yet to occur, the interest in them has been more than satisfactory. We will be hosting two workshops, one in early August and the other in mid-September, on the development and implementation of LTS efforts. We expect that the impacts of these workshops will be felt for some years to follow as one of the aims of the workshops is to initiate and sustain a community-of-practice for LTS efforts in engineering programs throughout the country.

Challenges: The greatest challenge was coordinating the workshops. We had planned on having three workshops with 12 participants each. However, three (in Boston, Houghton, and Boulder) were shortened to two (Houghton and Boulder) to create cost-effective workshop sizes and fit to applicant schedules. We dealt with this issue by expanding the workshop sizes (to 18 each) at two locations so as to accommodate all original invitees to the workshops. We are now scheduled with up to 19 participants at each location.

228
PI: Patrick Tebbe
Institution: Minnesota State University Mankato
Project Title: Full Development of Engineering Scenarios to Promote Student Engagement in Thermodynamics Related Courses
Project Number: 0920436
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The full development of an Engineering Scenario textbook supplement for the engineering thermodynamics curriculum is the primary goal. The intended outcome through its use is improved student engagement and performance in thermodynamics related topics.

Methods & Strategies: Engineering Scenarios are supplements based on actual engineering facilities. Accompanying supplementary and background information promotes increased inquiry-based learning and leads to an increase in student engagement.

Evaluation Methods & Results: An advisory board of faculty, industry representatives, and current students will ensure the scenario elements reflect student interest and industry relevance. Assessment procedures will be based on the Phase 1 project and will use quantitative (pre- and post- concept evaluation, engagement surveys) and qualitative (focus groups, survey groups, classroom observation) techniques under the direction of an assessment supervisor.

Dissemination: Assessment results will continue to be published in relevant conferences and journals. A website from the Phase I project is already in existence, with an updated site to go online during Summer 2012. Conference workshops and possible professional publication are planned.

Impact: For Phase I, we found greater student engagement, improved faculty understanding of learner requirements, and the development of several undergraduate assistants into 'students as experts' as key impacts. With Phase II these results will continue to grow as the material is expanded and tested by other institutions. If successful, the overall impact will be more student interest and improved performance in thermodynamics. An additional impact was that it expanded knowledge on creating appropriate learning tools for students.

Challenges: The determination of the best concept inventory and engagement assessment tools has been challenging.
Ensuring that sufficient and valid statistical data is obtained from the expanded site testing is the primary concern. The resulting IRB issues/questions are also time consuming. To help with this we have been utilizing a campus research support center for advice on the research statistics involved.

A second challenge has been performing the level of instructional programming and graphics formatting required for the material.

229
PI: Beth Todd
Institution: University of Alabama
Project Title: The Coach
Project Number: 0942330
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The overarching goal of the project is to improve the quality of freshman engineering students' writing. This is done with a web-based instructional module that models widely used classroom and workplace documents. The module includes a series of rhetorically-grounded writing prompts.

Methods & Strategies: The project has begun with the development of a module for writing a technical report. Following this, development of modules for other documents should take a subset of the existing programming. The module has been implemented in multiple section courses to include a control group.

Evaluation Methods & Results: The evaluation consists of both qualitative and quantitative measurements. Samples of writing assignments will be taken from sections using the module as well as control sections. Students using the module will also complete a questionnaire on their experience with their writing assignment. Additionally a focus group will be used to improve understanding of what the students appreciate about the modules. Initial evaluation data is being compiled.

Dissemination: A paper has been submitted to the International Mechanical Engineering Congress and Exposition. Papers are planned for future ASEE conferences.

Impact: The project is early in determining its impact, but it has led to discussions among a variety of engineering faculty on the characteristics of good technical writing. It is anticipated that this tool will be helpful to students in improving their writing but also helpful to technically trained instructors who may not have strong pedagogical skills in writing.

Challenges: The team is composed of faculty from Engineering, Computer Science, and English. The Engineering and English faculty are learning to appreciate the complexities and limitations of programming the modules. It is becoming clearer that programmers don't write the same type of documents as do other engineers. We are working to solve this challenge by continuing meetings and collaborations.

230
PI: Jennifer Turns
Institution: University of Washington
Project Title: Identifying Implications: Using Personas to Bridge the Gap Between Research findings and the Design of Educational Experiences
Project Number: 1044500
Type: Phase 1/Type 1 - Exploratory
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: We are exploring the effectiveness of using personas (a tool from the field of human centered design) in educator workshops and educator design sessions as a means to help engineering educators become familiar with and ultimately leverage engineering education research.

Methods & Strategies: The educator workshops consist of participants studying individual personas, small groups talking about individual personas, and group-wide discussion. The educator design sessions involve bringing personas into more individualized sessions with educators.

Evaluation Methods & Results: Our research design is based on the design experiment methodology. Consistent with the design experiment approach, we will treat each workshop/design session as a case. The data collection for each case (i.e., each instance of a workshop or design session) will be as follows: (1) observation of workshop sessions, (2) facilitated recall/structured debriefing of the facilitator, (3) post surveys with all participants, (4) post interviews with selected participants, (5) follow-up surveys with all participants, and (6) follow-up interviews with selected participants.

Dissemination: Our ultimate goal is to disseminate our approaches through a culminating workshop to the engineering education community and a facilitator guide, and our research results through technical reports and a publication in a Scholarship of Teaching and Learning Journal. To date, we have run one workshop at the POD conference and submitted a conference paper to the Frontiers in Education conference.

Impact: We anticipate impacts in two areas: knowledge about students and informed decision making. Concerning knowledge about students, we are asking: To what extent do the personas initiate discussions where participants compare the personas to their own understanding of their students? Does this help participants get beyond stereotypes, and develop empathy for a
range of student experiences? Concerning informed decision making, we are asking: What range of teaching ideas (particularly actionable, novel ideas) emerge and are ultimately enacted?

**Challenges:** Not applicable

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### 231

**PI:** Stephen Turns  
**Institution:** Pennsylvania State University  
**Project Title:** Improving Students’ Problem-solving in Thermodynamics  
**Project Number:** 1043833  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We intend to develop an intervention to support students’ Thermodynamics understanding and problem solving and an assessment of Thermodynamics reasoning ability. At the end of this project, we will conduct an experimental test of the intervention and an evaluation of the reasoning instrument.

**Methods & Strategies:** Our intervention uses a matrix, with video instruction, to scaffold students’ thinking about the relations between concepts and the tools for representing them (e.g., graphs). The Thermodynamics Reasoning Inventory (TRI) assesses students’ ability to reason with Thermodynamics concepts.

**Evaluation Methods & Results:** Think aloud studies and a pilot test have evaluated the intervention. The pilot test shows benefits for students with average and above Thermodynamics grades, but think alouds reveal piecemeal processing of matrix contents. We added relational thinking prompts and design experiments have further informed the intervention. Students also completed TRI items and supplied justifications for responses. We used these justifications to write multiple-choice distracters that are sensitive to common misconceptions. A test of the intervention and a full evaluation of the TRI are scheduled for Fall ’12.

**Dissemination:** This project is in an early stage. We have met with our external advisor and prepared a conference paper. In the future, we will make the intervention available through a publisher and provide electronic access to the TRI. We will share project findings through conferences, workshops, and publications.

**Impact:** Our project is in early stages and the impacts have not been fully evaluated. Preliminary results suggest that the matrix intervention will support students’ conceptual understanding and reasoning with Thermodynamics concepts. The TRI will yield a measure of students’ Thermodynamics reasoning. Within project parameters the TRI will evaluate the effects of the intervention. We also expect the TRI to be used by other Thermodynamics instructors who are interested in knowing more about their students’ understanding of key concepts.

**Challenges:** We have not yet experienced any unexpected challenges.

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### 232

**PI:** Nelson Uhan  
**Institution:** Purdue University  
**Project Title:** The POET Project: Investigating the Use of Visualization to Effectively Teach Optimization Modeling Skills  
**Project Number:** 1044182  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The objective of our project is to develop, evaluate and improve a web-based, interactive learning environment for teaching mathematical optimization modeling skills.

**Methods & Strategies:** Using web-based technologies (in particular, Flash/ActionScript, PHP), we are currently developing POET (Purdue Optimization modeling Education Tool), an interactive learning environment that teaches students to formulate valid and tractable mathematical optimization models, by providing visual tools to help students better conceptually grasp the underlying problem and self-assess their work. We are evaluating the effectiveness of POET in the learning of optimization modeling skills, through measures of student performance on exams and quizzes, surveys, interviews, and controlled lab studies. Finally, we expect to establish a web-based platform to raise awareness of POET, and grow a network of students and instructors around the world who can use and evaluate the latest version of POET.

**Evaluation Methods & Results:** We performed an in-depth analysis of common student errors on five quizzes given to students in IE 335 (Purdue’s undergraduate mathematical optimization class) in the Spring 2011 semester. Our analysis of common student errors in linear programming modeling word problems resulted in an extensive taxonomy of common student errors in these problems. We found many errors that indicated that the students had little or no understanding of how mathematical expressions related to the requirements imposed by the word problem, and that students often resorted to a direct translation approach, in which they tried to construct mathematical expressions by matching the given decision variables with the sentences in the word problem word-forward.

We also tested a preliminary version of our tool, POETIC on multiple populations. In October 2011, we conducted an experiment with 200 participants using Amazon’s crowdsourcing platform, Mechanical Turk. We repeated the experiment with
90 IE 335 students in January 2012. In both of these experiments, students were given 5 simple modeling problems to solve without an interface, and then 5 additional problems to solve using variations of the POETIC interface. We found that POETIC had positive short-term and long-term effects in reducing errors in simple modeling problems.

**Dissemination:** We have developed a wiki-based website for POET (https://engineering.purdue.edu/POET/) to disseminate project outcomes, including the interactive visual environment itself, POET. To generate discussion about our work with other scholars in our disciplinary fields, we have shared our preliminary results via conference presentations to both the operations research field (at the INFORMS Annual Meeting in 2011 in Charlotte, NC, including educators from both engineering and business schools) and the mathematics education field (at the upcoming ICME-12 Conference in Seoul, Korea). We have also submitted a conference paper to PMENA 2012. Finally, we are in the midst of preparing two articles based on our work so far for submission to journals in mathematics education and human-computer interaction.

**Impact:** At the completion of this project, we expect to have designed and produced a web-based, interactive learning environment, POET, which will enhance the learning of optimization modeling skills for undergraduate engineering students. To the best of our knowledge, this interactive learning environment is the first of its kind for optimization modeling. In addition, we anticipate that the educational insights produced by our project will represent a significant step in gaining a systematic understanding of the learning process for optimization modeling, and more generally, for modeling in operations research. This is an area of STEM education that has largely been untouched, with only some existing exploratory research.

**Challenges:** Our most significant challenge has been getting students to agree to participate in clinical interviews with the researchers to gather follow-up information on their use and understanding of our visualization tools. We intend to change our incentives to try to address this problem in the future.

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**Poster Abstracts**

**233**

**PI:** John Uhran  
**Institution:** Univ of Notre Dame  
**Project Title:** On Engineering Education: The Role of the First Year  
**Project Number:** 0735633  
**Type:** Other  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** Our purpose is to increase the STEM population thru sharing and disseminating best practices in First Year engineering education, first through meeting and sharing at the workshop(FYEE), a unique event, and then through networking.

**Methods & Strategies:** Each of the first 3 workshops created a learning/sharing experience for each participant. The 4th will consist of four distinct facilitated workshops on topics related to the first year experience followed by a series of Best Practice presentations by the conference attendees on the same topics.

**Evaluation Methods & Results:** We have collected and categorized the information presented and discussed at these series of conferences including transcripts of lectures, open forum discussions, and Q & A sessions, as well as surveys distributed to conference attendees. Subsequent meetings took these comments into account. This has provided a plethora of information on the current best practices within the field of Engineering and the means of disseminating that information to others. Some participants have contributed papers to various ASEE meetings after attending and an evaluation of successes and failures will be done at end.

**Dissemination:** Each of the earlier workshops recorded all presentations and talks and were produced on DVD’s for dissemination along with summaries of key points of every segment. This practice will continue and by having the 4th workshop at Univ of Pittsburgh some geographic diversity will also be provided.

**Impact:** Feedback from the conferences has been very positive both from the students involved as recorders and panelists and the other participants. It has provided fellow faculty members the opportunity to network and hear of the best practices from a number of departments across the country. Passing along these practices will give first year students a better chance at assimilating into college life. Student panels have also been used to provide insight on their perspective for faculty and administrators as well. A long range survey of earlier participants will hopefully yield more complete data.

**Challenges:** A majority of our difficulties have come in the form of funding, location, and mixed ideas for best setup of the conferences to increase efficiency, communication, and to cover the most pertinent information. Registration fees and travel costs are also a problem for many who are typically teaching rather than research focused. Some changes that were included were student panels, smaller discussion groups, and webcam conferencing to increase the access for audience. We also began to solicit corporate sponsors which helped to reduce registration fees and to bring in top keynote speakers.

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**234**

**PI:** Bernard Van Wie  
**Institution:** Washington State University  
**Project Title:** Multi-Disciplinary Project-Based Paradigm that Uses Hands-on Desktop Learning Modules and Modern Learning
Pedagogies

**Project Number:** 1023121  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:**  
Outcome 1: New CE, ME, BE, ChE and EE cartridges developed & tested.  
Outcome 2: Commercial desktop learning module designed & marketed.  
Outcome 3: Pedagogy disseminated to larger community.  
Outcome 4: DLM tested in a design-project based CHAPL implementation.

**Methods & Strategies:** Workshops for new faculty participants; strategic design discussions with 3 companies; development of worksheets and pre- and post-implementation quizzes and exam questions that coincide with Fink's Taxonomy of Significant Learning; Assessment of Cooperative, Hands-on Active Project-based Learning.

**Evaluation Methods & Results:** Concept inventories; Curricular debriefs; Use of a Fink's Taxonomy Rubric; Use of a Critical Thinking Rubric; Surveys for Attitudinal Assessment; Student Interviews; Pre- & Post Quiz and Exam Question Assessments; and Faculty Surveys.

**Dissemination:** Disseminated Desktop Learning Module to Civil Engineering, Mechanical Engineering and to three new Chemical Engineering professors.

With the introduction of new commercial Desktop Learning modules and accompanying workbook we expect other universities to volunteer to join.

**Impact:** Critical Thinking in the Collaborative, Hands-on, Active, Project-based Learning class improves to near graduating competency levels. Significant learning gains are demonstrated with a new rubric and surveys based on Fink's Taxonomy of Significant Learning. New faculty at our institution and other institutions are becoming convinced about the efficacy of the new Desktop Learning approach and use of accompanying pedagogy. Commercialization of Desktop Modules is expected to enhance participation.

**Challenges:** Desktop Learning Modules, even when simplified may prove more expensive than we thought so we have come up with a new alternative teaching mode with one unit at the front of the class and display via a Document Camera.

Challenges in recruitment of PhD students led us to work with a CE Masters student, undergraduates and a delay in arrival of ChE and BE PhD students. Contract issues with one company has led us to establish a relationship with another company. Challenges with teaching schedules led to introduction of new faculty.

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**235**

**PI:** Noe Vargas Hernandez  
**Institution:** University of Texas at El Paso  
**Project Title:** CCLI Phase II: COLLABORATIVE RESEARCH: Systematic Ideation Curriculum Effectiveness Investigation & Deployment to Enhance Design Learning  
**Project Number:** 0920446  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Our goal is to enhance design learning, more specifically, to improve the effectiveness of systematic ideation in the curriculum.

The outcomes include effectiveness analysis of TRIZ, Smartpen, and sketching for creativity and their implementation in the classroom.

**Methods & Strategies:** We run comparative design experiments with engineering students to study the effects of ideation variables (TRIZ, sketching, smartpen). We assess the results using effectiveness metrics and interpret them using cognitive and educational principles.

**Evaluation Methods & Results:** Part of our results have been published at conferences and submitted to various journals. Our results provide insight at the cognitive and practical mechanisms involved during design ideation.

Our evaluation plans include an external evaluator and an advisory board that periodically assess the project for formative and summative evaluation. These evaluations have allowed us to guide and fine tune our design experiments and obtain more relevant results.

**Dissemination:** We have disseminated our finding through conferences and journal publications. At this stage we are translating our results into practical undergraduate engineering education applications that will be disseminated broadly to design educators through workshops.

**Impact:** The PI's have implemented preliminary lessons in their classes with great success. We are at a stage that our findings are being converted into practical lesson plans and we have a preliminary group of colleagues at various institutions interested in implementing these lesson plans.

Increasing ideation effectiveness for design creativity is a very valuable skill of engineering students, and this has been recognized by departments, colleges and institutions since it is recognized that creativity is as important element of innovation.

**Challenges:** Creativity Design experiments are very complex and difficult to control. The PI's have a strong background and experience on these type of experiments. We have compiled our expertise on these experiments and created a set of
Goals & Intended Outcomes: The goal of this project is to establish strategies to design and implement “EFFECTs,” which is a critical thinking centered pedagogical method developed and validated during a Phase I project. This includes creation of additional active learning exercises that combine student practice of critical thinking and acquisition of the usual ‘body of knowledge’ information taught in engineering courses. This goal also includes the creation and expansion of a Community of Practice for EFFECTs users.

Methods & Strategies: Active learning exercises are created according to a pattern of asking students a ‘driving question’, for which they may initially only be able to offer a broad estimate as an answer, and then gradually instructing students on related fundamentals that will inform their ability to more directly answer the driving question. In doing this, students are given ‘guiding questions’ in an effort to encourage them to self-discover concepts, and ‘journal entries’ that require students to reflect on the learning process and articulate what they have understood.

Evaluation Methods & Results: Evaluation occurs at the level of individual project tasks; newly-authored EFFECTs are subjected to peer-review within the community of practice, and outcomes assessment once body-of-knowledge or scientific reasoning tests have been adopted to judge the pre/post impact on critical thinking and engineering judgment. Evaluation of student metacognitive reflection occurs on the basis of a previously-validated critical thinking rubric. The impact of the faculty communities of practice is assessed by interviews, surveys, and observations of the number of users, number of EFFECTs implemented, training workshop attendance, and so forth.

Dissemination: Several conference papers have been given (and others have been accepted for upcoming presentation) that address the activities associated with this project. Furthermore, a project website has been created that includes descriptions and support materials for the active learning exercises that have been developed. Finally, the community of practice is growing by direct invitation, word-of-mouth, and referral, to include STEM instructors in fields outside the original civil engineering environment in which EFFECTs was originally conceived.

Impact: We have observed a profound positive impact while implementing EFFECTs active learning exercises, with an emphasis on critical thinking and developing engineering judgment, in a way that is integrated with existing course content coverage. Faculty have been forced to re-consider the topics they teach from the standpoint of what decisions students will be faced with upon entering the engineering profession. Students have been given the opportunity to discover concepts for themselves, nudged gently along the way by instructors, rather than being taught fundamental principles outright. All the while, there has been a focus on finding ways to make instruction more ‘active’: more demonstrations, more
questioning of assumptions, more experimentation, more of asking how the pieces all fit together and why it matters. Overall, having EFFECTs as a common instructional technique has been a force that unifies the faculty in efforts to break free of existing patterns and find new ways to interest students and achieve the challenging outcomes of 'fostering environments that promote critical thinking.'

Challenges: With an emphasis on hands-on, active learning exercises, one of the challenges that has been faced is finding a way for 20-30 students to simultaneously be kept busy and engaged, when the available equipment resources may be limited. This has forced instructors to think in more detail about instructional sequencing, and has been an opportunity to develop lesson plans that combine experimentation with small group work, pre-activity discussion, and post-activity writing activities.

238
PI: Kimberly Warren
Institution: UNC Charlotte
Project Title: Development, Implementation, and Assessment of Geotechnical Concept Tools (GCT)
Project Number: 837647
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: 1) Develop a series of innovative Geotechnical Concept Tools (GCT) that will promote a student-centered, active learning environment in the classroom for a required Geotechnical Engineering course; 2) Implement the GCT and enhance the current curriculum to target multiple learning styles in the classroom with the goal of developing a model that can be replicated by other programs; 3) Evaluate the educational impact of the course modifications; 4) Stimulate increased interest in the field of geotechnical engineering and encourage advanced studies for all students including those that come from underrepresented groups.

Methods & Strategies: Two semesters of this course will be taught and assessed without the integration of GCT (to collect baseline data), and two semesters of the same course will then be taught with the implementation of the curriculum innovations (GCT) to determine the impact of creating an active learning atmosphere. An assessment expert will conduct a qualitative and quantitative assessment during the project. At the completion of this project, the design and construction methods of the GCT will be documented, the implementation plan will outline all techniques and curriculum used to implement the GCT into the classroom, and the finalized instruments and assessment results will be disseminated with the hope that the model developed during this project can be extrapolated to other engineering disciplines.

Evaluation Methods & Results: Both formative and summative evaluation is being conducted by the independent evaluator to assess the objectives of the project. Qualitative data from observation field notes, instructor teaching logs/reflections, and student interviews will be analyzed using constant comparison method from grounded theory where statements will be grouped by common themes. The emerging themes will be adapted during the data analysis procedures. Quantitative data from criteria-based assessments will be analyzed using statistical procedures. Control group data has been collected to provide baseline data for comparison with the data collected in the coming academic year after the GCT are implemented into the classroom. Quantitative data (pre-quizzes, tests, and final exams) will be compared between the two groups to determine the impact that the GCT has on comprehension and retention. Continued surveys and interviews will enable the evaluator to determine changes in perception, attitude, and their learning preferences as a result of increase classroom engagement.

Dissemination: This project is not mature enough for dissemination activities at this point.

Impact: Because the PI has only completed the two control group semesters at this point to collect the baseline data, the impact of this project is not yet known. The implementation group will be taught during the upcoming academic year. It is anticipated that the GCT will provide students with the active learning environment that they need to better comprehend and retain difficult civil engineering concepts. It is anticipated that their enthusiasm for the class and their understanding of real world application will increase.

Challenges: There have not been any unexpected challenges to date with regard to the project goals. However, due to personal reasons, the PI has had to request no-cost extensions, which has delayed the project two years.

239
PI: Christopher Williams
Institution: Virginia Tech
Project Title: Advancing Personalized Engineering Learning via an Adaptive Concept Map
Project Number: 1044790
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The primary objective of this proposed research is the implementation of an adaptive concept map cyberlearning tool that is capable of representing and conceptually linking together large amounts of information without inducing cognitive overload by representing the information visualization based on a learner’s personalized needs.
**Methods & Strategies:** We apply theoretical research on adaptive expertise, concept maps, and information visualization to design, develop and assess the cyberlearning tool. The “adaptive concept map” provides the user control over the quantity and level of detail of information displayed, thus providing a means for navigating content in a manner that is adaptable to their personal cognitive load needs.

**Evaluation Methods & Results:** Anticipated gains in students' meaningful learning will be measured across control and experimental groups by a series of structured problem solving observations and the Statics Concept Inventory Test. The tool will be implemented and assessed at two institutions to enable assessment of the transferability of the proposed innovation. Qualitative assessments will gauge usability and cognitive load. The progress of the project will be monitored by a formative assessment (i.e., pilot studies of the tool at the closure of the first year).

**Dissemination:** A prototype of the adaptive map cyberlearning tool is available at: http://128.173.188.251:8080/AdaptiveMap/index.html.

Thus far, the project has resulted in two peer-reviewed conference papers. We plan to disseminate the tool, assessment results, and an open software framework for others to add their curriculum to the tool.

**Impact:** Students: The developed tool will promote meaningful learning, positively affect students’ conceptual understanding of Statics concepts, and transition them towards adaptive expertise.

**Challenges:** Our largest challenge thus far was in software development. The creation of a wholly new software is quite challenging. To address this challenge, we have engaged a total of six undergraduate Computer Science students in undergraduate research. As a result, we were able to create the software tool with very limited resources, while also providing the students with a rewarding research experience.

**240**

**PI:** Robert Williams

**Institution:** Ohio University

**Project Title:** Interactive Virtual Haptics-Augmented Statics and Dynamic Activities

**Project Number:** 0941224

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We have produced a new generation of animated, interactive, engaging, textbook-augmenting software activities, with haptic force feedback (feeling is believing), for augmenting the learning and teaching of basic and advanced undergraduate engineering courses nationwide. These exercises will allow the learner to concretely feel the action of the simulations.

**Methods & Strategies:** We will focus on discovering and applying appropriate educational pedagogical principles to improve the quality of education for all students in undergraduate engineering programs, rather than merely focusing on the technology.

**Evaluation Methods & Results:** Central to our project is continuing and intensive evaluations of the developed haptics-augmented engineering mechanics products to ascertain their utility, ensure realism and the meeting of educational needs, and to provide valuable feedback for product improvements, leading to commercialization. Instead of evaluation at the end of the development process, a Design Research approach in the evaluation process is used, making feedback an integral part of the development process. In this way, the evaluation will be primarily formative, with a summative piece at the end of the two-year project.

**Dissemination:** Our project results have been disseminated to date via one national conference in Education and one international conference in Engineering. A journal manuscript will be prepared and submitted in Summer 2012. Our long-term goal is commercialization of the resulting project products. Ohio University is providing business personnel and students in the Voinovich School to work with the PI and co-PI for performing market studies, developing a business plan, and commercializing research/education product results.

**Impact:** Too often, the problems found in basic undergraduate engineering mechanics courses are flat, abstract and static. Some students find themselves unable to connect with the material. Equations and formulas become ends in themselves. Students with this idea, through no fault of their own, miss the point; engineering is a concrete activity that makes a difference in people’s lives. Students who have not had the opportunity to make this connection between the abstract and the concrete are at a disadvantage. In many cases, this leads to failure or worse, students self-selecting themselves out of the field. Even for the best students, current practices do not engage them fully, and deep learning, understanding, and retention of fundamental principles may not be achieved.

Further, engineering students who drop out, or are forced out, are disproportionately women and minority students (two-thirds of underrepresented students drop out vs. only one-third of others, Hargrove and Burge, 2002). Therefore, success in our project may help to increase the diversity of our engineering workforce.

**Challenges:** None.
241
PI: Tao Zhang
Institution: New York Institute of Technology
Project Title: Enhancing the Electrical and Computer Engineering Curriculum by Integrating Applications of Wireless Technology
Project Number: 1044596
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goals are 1) to create a wireless communications and networking concentration in ECE program; 2) to attract and motivate undergraduate engineering students, especially females, to pursue this concentration of study. The intended outcomes are that instructional materials will be designed for this concentration.

Methods & Strategies: Create a connected scope and sequence of learning outcomes to improve the ECE curriculum by integrating application-oriented wireless network projects related to healthcare applications into the curriculum.

Evaluation Methods & Results: The Evaluation Plan includes examination of curriculum enhancements, i.e. instructional plans and project assignments; student performance assessments and faculty course assessment reports; enrollment and retention records; surveys of student attitudes toward pursuing careers in ECE; and monitoring of dissemination activities.

Two surveys of student attitudes have been conducted and data has been collected. The external evaluator interviewed the instructors who teach the courses in the specified course stream. Currently, it is in the process of forming an evaluation subcommittee.

Dissemination: PI and Co-PI presented the proposed work to NYIT Faculty Interdisciplinary Research Series. The senior design project was demonstrated to incoming freshmen during Preview Day activity. A workshop will be organized for dissemination activity.

Impact: The project provides undergraduate students in ECE with hands-on opportunities to explore, design, and research wireless networks applications to monitoring systems, through collaboration between the SoECS and the NYIT NYCOM. Students participate in problem-based bioengineering projects that integrate engineering principles with biology and medical applications. The PIs and the Co-Investigator will supervise implementing and testing in authentic testbeds. Faculty provides continuous feedback to support student learning, ensure instructional effectiveness, gauge student interest and maintain appropriate academic rigor.

Challenges: The project is going well so far.

242
PI: Yongpeng Zhang
Institution: Prairie View A&M University
Project Title: Developing Virtual and Remote Undergraduate Laboratory for Engineering Technology
Project Number: 0942807
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: This project is to extend traditional laboratories with Virtual and Remote (VR) functionalities. Outcomes include: Develop VR-teaching materials in combination with hands-on labs; Deploy new technologies and infrastructure; Enhance the professional development of faculty members; etc.

Methods & Strategies: Leveraging on the previous project which has revamped existing labs with LabVIEW, this project is to further develop virtual and remote functionalities on top of the LabVIEW-based laboratory.

Evaluation Methods & Results: One external consultant is hired to strengthen the evaluation. Project progress is monitored by PI and evaluator; student surveys are conducted by the end of each semester. Based on the problem encountered, project plan is adjusted to achieve the promised standard.

Dissemination: This project has been presented in professional conferences, faculty workshop, student symposium, and K-12 career exhibition as well; also it has been exposed in open house activities to attracted potential transfer students from 2-year colleges.

Impact: The project demo has raised fantastic responses among visitors from 2-year college, which greatly enhanced their interests to continue upper-level undergraduate study here; departmental colleagues expressed their strong motivations to participate in the following projects; this project promoted the inter-institutional collaboration among three universities in the Houston area.

Challenges: Online lab management system development is lag of the schedule. One external consultant and one faculty in computer science are hired to accelerate the progress.

243
PI: Weihao Zhao
Institution: University of Miami
Project Title: Collaborative Development and Application of Distributable, Internet Accessible, Interactive Medical Imaging Teaching Software and Dynamic Tracking System
Project Number: 1022750
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies
Goals & Intended Outcomes: The project's goal is to create a set of contemporary teaching materials and interactive learning environment for medical imaging education, through which engineering students will be able to design components and to conduct simulations for commonly used medical imaging systems.

Methods & Strategies: The developed Internet accessible, interactive, module-based coursework, featuring user-controlled animations and simulations to demonstrate physics principles and engineering implementation, is applied through a hybrid teaching method and monitored by an online tracking system.

Evaluation Methods & Results: A dynamic assessment tracking system (DATS) was created to associate with the online medical imaging teaching software (MITS). The MITS/DATS design assesses dynamically student's engagement, learning gain for pre/post module (lecture topic), pre/post modality (imaging technology), and collection of open-end surveys. For the past three years, student’s understanding on concepts and conducting projects have improved significantly (ANOVA single factor, p<0.05). However, subjective perception surveys showed disparities between junior and senior classes.

Dissemination: Progress reports have been presented at IEEE/FIE 2010 and ASEE 2011. A manuscript has been published on The Open Medical Imaging Journal in 2011. More than 10 universities (national and international) are using the MITS/DATS system. A national workshop will be held in 2013.

Impact: Three local institutions are participating in this project. At the same time, each offers undergraduate and graduate medical imaging courses by using the developed system. An interested instructor can apply and get an instructor’s account so that he/she can enroll his/her students to the system and assess their performance online independently. Colleagues in the PI’s institution have been motivated by the project’s teaching revolution and have planned to develop other applications in different fields. Local community colleges also plan to use the system.

Challenges: Evaluations showed subjective perception disparities between junior and senior classes by using the developed system. Another challenge is how to accommodate the teaching modules by different instructors from different institution through the same system. This raises the question of 'universalizing' the MITS/DATS system. We try to break down the teaching modules as detailed as possible so that instructors or students can adaptively select the topic for teaching or learning.

244
PI: Wei Zheng
Institution: Jackson State University
Project Title: Novel Development of Lab and Course Modules: Integrate Intelligent Structure Technology and Self-Regulated Learning to Inspire Motivated and Strategic Learners in STEM

Project Number: 0837395
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To improve diverse students' perception towards STEM and enhance their motivation, confidence, and strategies in learning STEM; to expand faculty's expertise in fostering students-centered inquiry-based active learning; and to broaden participation of underrepresented groups in STEM.

Methods & Strategies: The proposed instructional strategy framework is based on well-developed cognitive models, others' successful STEM educational practices, and the PI’s prior validated experience. It could have high potential to achieve its expected outcomes. The features of the instructional strategy framework includes (1) enhancing students’ motivation for their efforts and persistence in learning STEM; (2) developing their strategies for self-reflection and utilization of learning recourse (e.g. support from peer and faculty); and (3) improving their learning environment and recourse.

Evaluation Methods & Results: Motivation Strategies for Learning Questionnaire (MSLQ) and Self-Regulated Learning Inventory (SRL) was utilized to evaluate students' gains related to SRL components and strategies. Those questionnaires were selected and slightly modified to fit the project evaluation for each Self-Regulated Learning (SRL) component. Additional questionnaires were also developed by PIs to directly assess the effectiveness of teaching material and strategies. The current and previous grades of students were also utilized as a quantifiable instrument for measuring students' performance.

Dissemination: Three ASEE conference papers for implementing instructional strategies in different discipline courses have been published in the past. One paper has been accepted in the coming ASEE annul conference. Discussion and implementation of instructional strategies among extended faculty team beyond the PI’s team has been carried out.

Impact: The impacts of implementation of self-Regulated Learning (SRL) instruction on students' learning outcomes are assessed based on students' academic performance that is indicated by the students' course grade. The students from the course with SRL instruction are made of intervention group. The students from the same course without implementation of SRL in the past four years are regarded as empirical control group. The comparison of outcomes from the two year implementation indicates that there is a trend of increasing students' learning performance through implementing SRL assessment. The junior students were impacted beneficially much more than the senior students.

Challenges: Some students have misconception on the significance of implementing self-regulated learning (SRL)
assessment. They thought that SRL only means self-directed learning and did not realize that the importance of making a plan, using strategies, and reflecting and adjusting learning activities in the learning process. In the subsequent implementation, attention was made to avoid this misconception, and make sure that students understand that SRL is a comprehensive cognitive model for learning regardless of learning setting of class lectures, self-directed learning, or other forms.

245

**PI:** Richard Zollars  
**Institution:** Washington State University  
**Project Title:** Exploring Studio-Based Learning in Chemical Engineering Education  
**Project Number:** 1023112  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** The goal is to develop two software programs and associated teaching materials to help students succeed in a gateway chemical engineering course. The outcome would be greater retention of engineering students as well as increased learning by the students.

**Methods & Strategies:** One of the software packages being developed allows the use of a studio-based, asynchronous teaching approach in engineering classes. The other provides a scaffolded environment to help students master class material and provides a communications format for the asynchronous software.

**Evaluation Methods & Results:** The material/energy balance class at eight institutions is being taught in its normal fashion this year. Students solve a typical homework/exam problem and a problem critiquing an existing solution at the start of the class as well as complete an attitudinal survey. They are given the same problems and survey at the end of the class. Next year the class will be taught using a studio-based approach. Students will solve the same problems and take the same surveys. Comparing the results between the two classes will demonstrate the effectiveness of the approach.

**Dissemination:** We held a workshop amongst the participating institutions in 2011 to introduce the scaffolding software. A similar workshop will be held in 2012 to introduce the asynchronous discussion software. Presentations describing the project have been given at ASEE and AIChE meetings.

**Impact:** This project is in its first year. Our intent is to implement two novel approaches into engineering education. The first is a visually based software tool that will help students in gateway classes by building on their preferred learning style. The second, studio-based instruction, is used in other disciplines and has the strengths of incorporating all cognitive levels of Bloom's taxonomy. Implementing this in an asynchronous manner overcomes class period time limits. Combining these two approaches will reduce the loss of students by increasing the effectiveness of instruction.

**Challenges:** A challenge has been dealing with the varied academic schedules at the participating institutions as well as the different manners in which the material/energy balance class is taught (both topics in one term, separate terms, just-in-time). To accommodate these we developed separate problems depending upon the depth of coverage in the participating class. Since the assessment is based on changes from the beginning to the end of a class not all participating classes and assessment materials have to cover the same amount of material.

**GEOLOGICAL SCIENCES**

246

**PI:** Matthew Bampton  
**Institution:** University of Southern Maine  
**Project Title:** Creating and Implementing a Concept Inventory-Based Diagnostic Tool to Improve Undergraduate GIS Education  
**Project Number:** 0837259  
**Type:** Adaptation and Implementation (A&I)  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** Create a concept-inventory based tool to identify misconceptions hampering student learning of GIS

**Methods & Strategies:**
- An open-ended qualitative survey
- Interviews and focus groups
- An objective instrument

**Evaluation Methods & Results:**
- Focus group of participating PIs and Senior Personnel
- Administration of open-ended instrument at six institutions, twice each
- Follow-up interviews and focus groups with participating students
- Transcription, processing, and analysis of resulting interview records


**Impact:** Anticipated impacts include:
1. Increased completion rates among undergraduate GIS students
2. Improved outcomes in undergraduate GIS students
3. Improved teaching among GIS faculty
4. Baseline data describing undergraduate GIS knowledge against which to calibrate future developments of curriculum

**Challenges:** Significant challenges arose in three key areas:
1. Processing open-ended instrument results was extremely time-consuming
2. Administering, transcribing, processing, and analyzing interview and focus-group data was extremely time consuming
3. Working with rapidly changing technology, both in the instructional and the assessment environment

These challenges were addressed by consulting with colleagues experienced in working with these types of materials

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### 247

**PI:** Karin Block  
**Institution:** City College of New York  
**Project Title:** The Geoscience Student Data Network: A Cyberinfrastructure-based Approach for Collaborative Classroom-, Field-, and Laboratory-based, Undergraduate Education  
**Project Number:** 0942282  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** This project is developing a platform-independent software, the Geoscience Student Data Network (GSDNet) to train students to acquire, submit, process, and integrate data from multiple sources. The curriculum is designed to establish a cyberinfrastructure-based collaboration between students from the City College of New York and Boise State University -- two distinct geographic and cultural backgrounds.

**Methods & Strategies:** The GSDNet software employs private ProjectSpace and public GeoBook that will be tested as part of a curriculum that trains future workforce geoscientists in state-of-the-art geochemistry analytical techniques, geoinformatics technology, data acquisition, and GIS analysis and manipulation. The curriculum devised to accompany software development provides opportunities for students to conduct research on the applied research theme of geothermal energy resources to leverage resources of the NSF and DOE funded cyberinfrastructure projects, GeoStrat and the National Geothermal Data System.

**Evaluation Methods & Results:** The project is conducting course outcome and course level assessment on the effectiveness of the curriculum and tools on student learning. We will perform a summative evaluation from follow-up statistics performed at each institution to track the subsequent advancement of geoscience majors in general to graduate school or environmental fields.

**Dissemination:** Upon release, the GSDNet software and results will be disseminated via conference presentations and publication in peer-reviewed journals. Additionally, we will offer a webinar using Boise State’s GotoMeeting facilities targeted at faculty from community colleges and undergraduate institutions and at database partners such as EarthChem/IEDA and GeoStrat. The webinar will be advertised through regional societies and professional societies (e.g., GSA and AAPG).

**Impact:** The curriculum developed in tandem with the GSDNet is being implemented as part of existing Earth and Atmospheric Sciences core curriculum at CCNY. If successful, the software will be incorporated permanently into the curriculum. We expect to prepare students for workforce and research careers in the geosciences by providing tools and helping them acquire expertise in handling data.

**Challenges:** The project has so far implemented two courses to prepare students for field data collection and research projects and to collect information for the GSDNet prototype development. The Geothermal Energy Resources course was offered in Fall 2011 at both institutions with mixed results. The technology utilized for social networking and distance learning relies on a heavily taxed network and facilities that are in the process of being updated. As a result communication was often interrupted and created frustration among students at both institutions.

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### 248

**PI:** Declan De Paor  
**Institution:** Old Dominion University  
**Project Title:** Scaffolding Undergraduate Geoscience Inquiry Using New Loggable Google Earth Explorations  
**Project Number:** 1034643  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Using Google Earth with COLLADA and our own field data to create student-centered interactive virtual field trips for geoscience education, featuring computer logging and scaffolding of student actions with automated feedback and support.

**Methods & Strategies:** Using Google Earth Tours, Gigapans, draped geologic maps, cross sections, virtual specimens, virtual field tools (virtual hammer for specimens, drill, etc). Using the Google Earth API to develop controls such as emergent cross sections.

**Evaluation Methods & Results:** Pre- and post tests found: overall learning gains; no differences in learning gains when comparing those with prior coursework in geology or geography to students without this prior coursework; no differences in learning gains when comparing males and females. Gender
difficulties favoring males in terms of items completed during class period and correlation between students’ pretest and embedded laboratory scores.

**Dissemination:**
3. Workshops and presentations at regional & national meetings

**Impact:** Students responded enthusiastically to VFTs in lab. Hamilton College organized research group to develop related materials. Several colleagues were trained in Gigapan use at Google Penrose Conference. Two publishers expressed interest in bundling our work with their texts. Geoscience Canada added a special section for peer-reviewed papers on virtual visualizations and appointed our PI as associate editor.

**Challenges:** New versions of Google Earth software required us to change our approach to visualizing the sub-surface for geological and geophysical investigations. This ended up as a benefit as we developed better approaches.

COLLADA model file size lead to loading difficulties which we are tackling by image tiling, etc. Exercises near the poles and anti-meridian encountered code bugs. We draped Blue Marble ground overlay and shifted its origin of latitude. Still working on poles.

249
PI: Jan Hodder
Institution: Oregon Institute of Marine Biology
Project Title: Collaborative Research: Supporting and Advancing Geoscience Education at Two-Year Colleges Through Workshops and Web Resources
Project Number: 1122640
Type: Phase 2/Type 2 - Expansion
Focus: Developing Faculty Expertise

**Goals & Intended Outcomes:** To provide a professional development program for two-year college (2YC) faculty that develops strategies for teaching to all students and for preparing 2YC students for the workforce. Outcomes include models of professional development, a topical resource base and a geoscience faculty network.

**Methods & Strategies:** Two national workshops and dissemination workshops at professional societies, and at regional and local venues. Virtual workshops. Online resources including an associated website. A leadership development program for 2YC geoscience faculty members.

**Evaluation Methods & Results:** The evaluation plan includes end-of-workshop and follow-up surveys, focus groups and interviews. The summative evaluation looks at the impact of participation on individual teaching practices and on geoscience programs, departments, and institutions. It will also assess the success of the different professional development models implemented by the project, and look at whether the project supported the development of a faculty network and leadership capacity within the 2YC faculty. It will determine if there is evidence of a national impact.

**Dissemination:** Our project is about dissemination and includes the following mechanisms through which this will be achieved: 1) National, regional and local workshops for 2YC faculty. 2) Workshops and sessions at professional meetings. 3) Virtual workshops and online web resources.

**Impact:** The impact of the professional development activities provided by this project will occur at several levels depending upon the needs and challenges of the participating 2YC faculty. We anticipate impact on individual teaching practices, on geoscience programs, departments, and institutions, and on the professional societies that support geoscience research and education. Specifically we anticipate that participating two and four-year faculty will develop skills and knowledge that will lead to changes in how they approach career preparation and their efforts to teach to all students.

**Challenges:** We have not yet offered any programmatic activities so have no information for this topic.

250
PI: John Horel
Institution: University of Utah
Project Title: Observing Snow and Wind: Using the Environment to Engage Students in Science and Engineering
Project Number: 0940558
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** (1) to increase student proficiency related to the underlying principles and sources of uncertainty associated with environmental instrumentation and (2) to enhance student confidence to use technologies to observe the environment and solve real-world problems.

**Methods & Strategies:** With support from the NSF Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) program and a substantive equipment donation from Campbell Scientific, Inc., we have developed an instrumentation laboratory used for instruction for non-science as well as science majors.

**Evaluation Methods & Results:**
- Baseline survey of faculty in May 2008
• Personal faculty interviews and group discussion with TAs and instructors
• Focus group discussion with undergraduates
• Conversations broken down into ~600 identifiable codes and assembled into 36 themes

**Dissemination:**
• Presented preliminary results at the American Meteorological Society Symposium on Education during January 2012.
• Paper describing this work in preparation for the Bulletin of the American Meteorological Society

**Impact:** A major revision to our undergraduate curriculum was implemented during Fall 2010. Among other changes, we now rely on half-semester courses to provide focused instruction on selected topics including a half-semester course on Environmental Instrumentation for undergraduate majors coupled with a semester-length course for graduate students. One of the most successful activities was to involve undergraduate STEM majors either as volunteers or enrolled in a half-semester course during a major NSF-funded field project: the Persistent Cold-Air Pool Study.

**Challenges:** Based on student and faculty input, we identified a number of challenges to the curriculum changes implemented to meet the project goals related to learning issues, teaching strategies, content challenges, motivation and engagement issues and the diverse mix of students enrolled in some of the courses.

**251**
PI: Mohammad Iqbal
Institution: University of Northern Iowa
Project Title: Field and Lab-based Activities for Undergraduate Students to Study the Hydrologic Environment
Project Number: 0836325
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** Provide undergraduate students lab and field-based experiences to understand water related issues, show how field data are used to implement best land use practices, and establish an outdoor data acquisition and transmission site to facilitate effective teaching of hydrology.

**Methods & Strategies:** I am using a 3-step model, (1) Classroom lectures to review theories, (2) On-campus experimental site activities to learn instrumental methods and analysis, and (3) Off-campus projects in watershed/wetland/prairie settings to assess learning.

**Evaluation Methods & Results:** A) Evaluate the quality and number of team projects, conference presentations and publications, B) Assess the new lab exercises developed through the project; (C) Find evidence of improved critical thinking skills and reasoning through essay questions, (D) Assess content knowledge test performance by giving pre and post-tests. So far pre and post-tests have been given in several classes, which showed significant increase in the number of correct answers on the post tests.

**Dissemination:** Presented papers at 6 professional conferences and presented new lab exercises at Earth Science Update conference and summer workshop in the department. On-going efforts include developing a real-time data transmission facility, and designing a website and refereed publication.

**Impact:** The project has already made a big impact on the instrumental capability of the department's hydrology lab. Many new pieces of equipment have been purchased, which triggered renewed research interests among undergraduate as well as graduate students. A new course in hydrology has been offered in the fall of 2009 and 2011. Students in 4 Earth Science courses and 2 Biology courses showed improved learning of hydrology, who also thought that they were better prepared for the job market. Also, our real-time data from the website have been used by Iowa's science teachers.

**Challenges:** The only unexpected challenge I encountered is the issue of automatically uploading water quality data from the on-campus well site to a remote network hub. I originally planned to use radio modem to transmit the data, but to avoid storm related interference the data are now being uploaded by buried cable.

**252**
PI: David Kinner
Institution: Western Carolina University
Project Title: Testing the Benefits of Undergraduate Research-Based Learning at Various Curricular Levels Using Authentic Research Questions in Hydrogeomorphology
Project Number: 1044623
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** Our project seeks to establish the student benefits of authentic undergraduate research experiences implemented in our classes. Each semester, students will complete an undergraduate hydrogeomorphology project that is related to our professional research. We will then try to evaluate how these experiences helped their learning and professional preparation.

**Methods & Strategies:** Students are given a piece of our research project. They are then responsible for coming up with a research question (the amount of guidance on this step varies) and going through the entire research process: determining sampling strategies, collecting and analyzing data and
presenting results. The amount of semester time devoted to the project depends on class level and objectives.

**Evaluation Methods & Results:** Methodologically, we are using both a Likert scale survey and focus groups to establish student perceived benefits of their experience. The survey is a modified form of the URSSA (2009) instrument which has been used primarily to assess student-perceived benefits of individual undergraduate research experiences. As the project continues, we may expand our evaluation towards understanding whether and how student understanding of the nature of science has shifted. We also hope to create a model for how research experiences can be implemented in undergraduate classes. URSSA, Undergraduate Research Student Self-Assessment (2009). Ethnography & Evaluation Research, University of Colorado at Boulder, Boulder, CO. www.salgsite.org

**Dissemination:** We hope to establish a comprehensive website this summer that will document our student’s scientific activities and our findings on research-based learning. We expect we will have results that can be presented at conferences (and later in journals) within the next year. We also hope to establish a presence on social media.

**Impact:** Anecdotally, students have responded positively to the opportunity to do science. We believe that this will benefit by having improved conceptual abilities, better hands-on skills, and an elevation of affective domain skills (i.e. confidence). We hope that this project will impact other faculty at our institution and in the STEM community by showing the benefits of doing research experiences in the classroom. If the benefits are great enough, others may also follow suit.

**Challenges:** Our major challenge was getting the grant several weeks before the beginning of the fall semester. Our implementation strategy was predicated on setting up a monitoring network, so part of student projects could include already collected data. Students could then be fit into an ongoing research effort rather than us having to generate a project idea for an individual class, thereby lowering an implementation barrier. This summer should allow us to have monitoring in place, allowing us to get students involved in ongoing research efforts.

**253**

**PI:** Heather Macdonald  
**Institution:** College of William and Mary  
**Project Title:** Collaborative Research: On the Cutting Edge: A Community Resource Transforming Geoscience Education  
**Project Number:** 1022910  
**Type:** Phase 3/Type 3 - Comprehensive  
**Focus:** Developing Faculty Expertise  

**Goals & Intended Outcomes:** The goal is to build a culture of sharing and communal improvement in support of undergraduate geoscience teaching. We use virtual and live experiences to increase the number of faculty who participate in our programs, enabling ongoing learning and promoting changes in teaching practice.

**Methods & Strategies:** We offer several workshops and other events each year using face-to-face, virtual, and hybrid formats. The website supports the geoscience community as well as workshop participants. We are revising the website to include expanded community-authored and community-reviewed resources.

**Evaluation Methods & Results:** We use a tiered evaluation that includes interviews, participant surveys, and national surveys of geoscience faculty. The combination of workshops and websites has influenced the practice of individual geoscience faculty in the classroom with a measurable shift toward active-learning strategies and promoted a culture in which faculty learn from each other. The project is evaluating the impact of the website using a combination of web metrics and qualitative data.

**Dissemination:** Our project is about dissemination. It includes face-to-face, virtual, and hybrid workshops, webinars and virtual journal clubs, topical email lists, collaborations with professional societies, and a website that has more than 40 topical sections and more 1500 community-contributed teaching activities.

**Impact:** The program has promoted a culture in which faculty learn from one another and share resources to improve teaching. The workshops encourage discussion about teaching and the website allows faculty to see what others are doing, to find ideas or materials for teaching, to find geoscience visualizations, and to obtain career planning information.

**Challenges:** Challenges have included managing and supporting such a large effort. We have dealt with this by adding new PIs, expanding our pool of workshop leaders, increasing support for the website and workshop leaders, and recruitment of community members to assume leadership roles.

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**254**

**PI:** David McConnell  
**Institution:** North Carolina State University  
**Project Title:** GARNET II: Self-Regulated Learning and the Affective Domain in Physical Geology  
**Project Number:** 1022917  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education  

**Goals & Intended Outcomes:** Our goal is to help students become better learners and our central hypothesis is that if our students develop effective self-regulated learning skills, then their attitudes will improve and that in turn will improve their learning and motivation regardless of instructional strategies employed.
**Methods & Strategies:** We used the Motivated Strategies for Learning Questionnaire to collect student self-reports of motivation and learning strategies. We compared MSLQ responses to interview data for about 50 students. We also collected pre/post data on student conceptual learning and made observations of instruction using the Reformed Teaching Observation Protocol (RTOP).

**Evaluation Methods & Results:** Comparing RTOP scores and student learning gains determined from pre/post test scores reveals that teaching style (RTOP) can explain more than a third of the variability in learning gains for introductory physical geology courses. Further, instructors in the high RTOP group had less decrease in student self-beliefs than instructors in the medium or low RTOP groups. Introductory geology instructors adopting improved instructional strategies can be more successful in buffering against an overall decline in student motivation.

**Dissemination:** The collaborating scientists have made multiple presentations at the national GSA and AGU meetings and have presented invited seminars at other institutions and as part of geoscience professional development workshops.

**Impact:** We will continue to document if and how students' beliefs about learning, motivation, and cognition vary among and across institutions, particularly among community colleges, private colleges, and four-year institutions. Further, we will establish one or more baselines detailing how students' beliefs about learning, motivation, and cognition change over the period of instruction. Finally, we will determine what kind of classroom activities and interventions promote student self-regulated learning and have the greatest positive influence on various subscales of the MSLQ.

**Challenges:** The principal challenges revolve around collecting data from additional institutions that were not members of the initial collaborative team. It is necessary to add private colleges and community colleges to get a representative sample of students from these types of institutions. However, this brings challenges in coordinating data collection in a consistent manner with our established practices. We have provided very specific information about the responsibilities of instructors in new institutions in an effort to make it more straightforward for other instructors to collect data in their classes.

**255**
**PI:** Eric Oches
**Institution:** Bentley University
**Project Title:** Integrating Earth and Environmental Science Education into a Business Curriculum Using Technology Enhanced Learning
**Project Number:** 0941131
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal is to improve science literacy among undergraduate business students through technology-based modules focused on complex problems related to sustainability. In bringing together faculty from different disciplines we are creating portable modules that can be tailored to a variety of courses.

**Methods & Strategies:** Through faculty workshops, we are developing problem-based modules that incorporate classroom and lab technology for teaching the multidisciplinary nature of problems in sustainability; these include stand-alone exercises for courses and common exercises for courses among several disciplines.

**Evaluation Methods & Results:** Our evaluation methods are two-fold. First, instructors in the workshops develop their own course-specific assessments based on the learning goals and objectives developed in the workshop. Second, based on a common set of goals and objectives for all the courses also developed as a group during the workshops we create a common pre- and post-test assessment to be administered in every class that employs the modules. Faculty develop these assessments after receiving training from an on-campus external evaluator. We are presently evaluating the results from the first years' assessments.

**Dissemination:** We have presented three papers on the workshops and preliminary results from modules at Geological Society of America meetings in Denver (2010) and Minneapolis (2011). We are preparing at least one manuscript for publication and will be presenting more results at GSA in Charlotte (2012).

**Impact:** Based on assessments in at least one course (Environmental Chemistry) we can measure a modest positive effect on student learning about water contamination. There has also been a positive impact among faculty in different disciplines in our most recent effort in developing a module on the sustainability of corn ethanol as an alternative fuel. With this module, we started branching out from the physical sciences into the fields of economics and public policy. At teaching workshops, a number of faculty have indicated interest in integrating the module into business (management) and IT.

**Challenges:** As with most curricular and pedagogical research, the biggest challenge has been developing assessment materials to effectively measure the impact of the modules. Although we have worked to clearly define our objectives, assessing learning with respect to the complex, interdisciplinary nature of sustainability is a serious challenge. To date, our common assessments for all of the courses have employed subjective essay questions designed to test critical thinking. Although we are still scoring tests and evaluating results, we have turned to discussions with colleagues to continue developing new ideas.
Poster Abstracts

256
Pi: Carol Ormand
Institution: Carleton College
Project Title: Developing and Testing Materials to Improve Spatial Skills in Upper Division Geoscience Courses
Project Number: 1044245
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Building on research from cognitive science, education research, and geoscience teaching, we are developing and testing a set of exercises and supporting materials aimed at improving the ability of upper division geoscience students to visualize geologic spatial relationships.

Methods & Strategies: In our first year, we are using pre- and post-tests of spatial thinking skills to evaluate spatial thinking gains associated with completion of a geoscience course. In subsequent years, the same tests will allow us to evaluate whether using our curricular materials results in greater gains in spatial thinking skills.

Evaluation Methods & Results: To evaluate the effectiveness of specific teaching methods and materials in developing students' penetrative thinking skill and their ability to apply this skill in geoscience, we are using a combination of standard psychometric tests and tests of penetrative thinking in geoscience contexts. In addition, faculty are documenting their classroom observations in weekly journals.

Dissemination: We are disseminating our plans and preliminary results via presentations at professional society conferences and the project website, and will write journal articles when we have results from the use of the new materials.

Impact: The project has the potential for broad impact both within and beyond the geosciences. These impacts begin with the direct impact on the students of participating faculty and extend outward through dissemination. Training in spatial thinking can eliminate gender differences, and spatial skills are a strong predictor of choosing STEM majors and careers. Thus training spatial thinking skills is one avenue to gender equity in STEM fields.

Challenges: N/A

257
Pi: Thomas Parham
Institution: Iowa State University
Project Title: Development of Cutting-edge Geoscience Virtual Reality Applications for Classroom Instruction and Pedagogical Evaluation of the Impact on VR Technology
Project Number: 0618686
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We seek to develop a 3D computer simulation that allows learners to actively explore volcanic systems. Aside from developing the program itself, we will also develop supporting materials and test the pedagogical efficacy of the combined curricular package to determine the affordances of our approach.

Methods & Strategies: We are employing user-centered design practices to determine essential functionality of the Virtual Volcano program and optimize our interface design. Concurrently, we are developing curricular support materials based upon the process-oriented guided inquiry learning (POGIL) model.

Evaluation Methods & Results: We have used a variety of evaluation techniques including interviews, observation of user behaviors via video screen capture, and administration of survey instruments before and after completing an activity with the software. Preliminary results indicate that the most recent build of Virtual Volcano is well suited to addressing certain concepts related to volcanic processes, but that the simulation technology also has the potential to inadvertently reinforce geospatially-rooted misconceptions and may result in over-estimation of both the frequency and severity of certain volcanic hazards.

Dissemination: We have taken the Virtual Volcano prototype to partner schools for field testing, run demonstrations at national conferences, and developed relationships with textbook publishers. The program is currently available for download from Iowa State and will be move to V-Hub this summer.

Impact: Virtual Volcano will have been used to teach more than 500 students about volcanism and volcanic hazards by the end of this academic year. Full scale implementation following the close of the project's development work stands to double that figure in the first year at Iowa State alone. To date, public reception has been overwhelmingly positive during national conferences, where faculty and staff from more than 50 institutions including universities, K-12 schools, museums, and national parks have signed up to be notified when the final build is released on V-Hub this summer.

Challenges: While central to the goals of the project, the use of cutting-edge VR and 3D computer simulation technologies meant we routinely encountered programming difficulties during prototype development. Balancing the desire for advanced features and graphics with the need for program stability proved especially challenging. We eventually overcame these delays by educating our entire design team in the human-computer interaction literature and hiring a top-quality developer with the advanced skill set necessary to help us realize our vision.
258

PI: Jill Singer

Institution: SUNY-Buffalo State College

Project Title: Collaborative: Faculty Development to Support High Impact Activities That Transform Undergraduate Geoscience Education

Project Number: 1134954

Type: Phase 2/Type 2 - Expansion

Focus: Developing Faculty Expertise

Goals & Intended Outcomes: This project is providing digital resources and faculty workshops aimed at building capacity within the geosciences community to increase both the quantity and quality of grant proposals submitted to the NSF TUES program and other NSF educational programs.

Methods & Strategies: The project conducts informational sessions and proposal writing workshops at national and sectional geosciences meetings. Two multi-day workshops will be held at the University of South Florida (2013, 2014) to help faculty develop ideas into full proposals. Digital FAQ resources will be based on faculty needs identified in our workshops.

Evaluation Methods & Results: Evaluation activities include collecting and analyzing metrics including the following: 1) Number of participants attending workshops and their prior experience with NSF; 2) Survey completed at end of each workshop; 3) Completion of a follow-up survey 6 months to one year after the workshop to assess follow-up mentoring provided by facilitator, status of proposal, and suggestions for improving the program; and 4) Embedded online questionnaire to gather information on impact from those who visit the website, including information on how they found out about the resources.

Dissemination: Our project website (http://www.buffalostate.edu/rtugeoed (Resources to Transform Undergraduate Geoscience Education) provides FAQs and slide sets with information about the TUES program, tips for preparing competitive proposals, templates for outlining a TUES proposals, and other resources. Video clips will be added during the summer/fall of 2012.

Impact: By targeting geoscience faculty at all institutional types across the country, this project has the potential to improve the quality of geoscience education for a very large number of undergraduate students, both within STEM majors and non-STEM majors. The efforts aimed at faculty that have not had previous NSF education funding should broaden participation by faculty and institutions that have had limited prior interaction with the geoscience education community. This in turn could lead to greater collaborations among faculty, strengthening the community of geoscience educators, and wider dissemination of existing and new resources. The digital resources should facilitate sharing of information to both faculty that participate in a project-sponsored workshop and to faculty that did not attend a workshop but access the information electronically.

Challenges: Primary challenges encountered relate to promoting informational sessions and workshops at already over-scheduled professional conferences. Related to this is attracting geoscientists to these sessions that are unfamiliar with DUE’s educational programs and in particular, the TUES program. Thus far our information sessions have had bigger audiences at meetings for audiences that are not frequent submitters of TUES proposals (Ocean/Atmospheric/integrated geoscience vs. traditional geology meetings), which is promising.

259

PI: Deanna Van Dijk

Institution: Calvin College

Project Title: First-Year Research in Earth Sciences (FYRES): Dunes

Project Number: 0942344

Type: Phase 1/Type 1 - Exploratory

Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goal of the First-Year Research in Earth Sciences (FYRES) project is to develop and implement a geoscience course in which first-semester students at Calvin College, mentored by upper-level students, learn science through engagement in undergraduate research experiences focused on Lake Michigan coastal dunes.

Methods & Strategies: The project includes one year for development of the first-year course and mentor program (structure, strategies and materials), followed by two years of implementation starting with teaching the course for the first time in Fall 2011. In FYRES, elements from the best existing models of inquiry-based learning, and undergraduate research experiences are combined and adapted to the focus on coastal dunes.

Evaluation Methods & Results: The FYRES project is evaluated with a pre/post-test design using semi-structured interviewing and on-line surveys (CURE). Additional methods included classroom observations and weekly journals completed by the students. Both the first-year student and upper-level student mentor experiences are evaluated. Data have been collected during the first course in Fall 2011 and during the continuation of the mentor experience in Spring 2012. Preliminary analysis of the data suggests that students were interested in the atypical course structure, they valued the instructional style and they felt the course met their expectations.

Dissemination: Although the project is in early stages, the PI co-led a workshop for faculty at a geographers conference, and she will give a seminar and conference presentation in Hong Kong. A first journal article submission is planned for summer
2013, with additional presentations, workshops and articles to follow.

**Impact:** Five undergraduate research students participated in developing the FYRES course and mentor program. In Fall 2012, 13 first-year students and 5 upper-level students participated in the FYRES experience. In Fall 2013, we expect 24 first-year students and 6 upper-level student mentors. Six of the upper-level students presented research results at a regional professional conference in March 2012. First-year students demonstrated engagement with the course material and research experience. We expect to find that FYRES fosters a continued engagement with the geosciences, but this it too early to track.

**Challenges:** Low enrollment was an unexpected challenge in Fall 2011. We have expanded our recruiting strategies to increase the number of students in Fall 2012. A second challenge was that the upper-level students significantly under-prepared and under-performed in their expected research and mentoring activities. We are revising the FYRES Research Mentor program structure for Fall 2012 to address the preparation and performance of the mentors.

**260**

**PI:** Ping Wang  
**Institution:** University of South Florida  
**Project Title:** Collaborative Research: Bringing Problem Solving in the Field into the Classroom: Developing and Assessing Virtual Field Trips for Teaching Sedimentary and Introductory Geology  
**Project Number:** 1044257  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The project is developing, implementing, and assessing new interactive field-based learning materials, in the form of virtual field trips, for teaching undergraduate sedimentary geology and introductory geology. The virtual field trip is based on a 4-day actual field trip for GLY4554.

**Methods & Strategies:** Two versions of the virtual field trip, one for advanced class and one for introductory class, are produced. The inquiry-based teaching strategy focuses on improving students’ ability to apply knowledge in making scientific observations and solving problems in a virtual field setting.

**Evaluation Methods & Results:** The project evaluation is carried out by the Coalition for Science Literacy (CSL). Currently we are at the very early stage of the project. The virtual field trip is evaluated based: assessments of student learning, student perception survey, and faculty perception. During the first year, evaluation will focus on the formative aspects to assist project leadership in its work to make the project effective and reach its goals. The summative evaluation which examines the extent to which results of the project are noteworthy will be conducted during the 2nd and 3rd years.

**Dissemination:** Once tested and refined, the virtual field trips will be disseminated through the broadly used web portals, such as SERC and Google Earth community, and workshops at regional and national meetings.

**Impact:** The intellectual impact of this project is in the testing, implementing, and refining the virtual concept in field trips. Despite the fact that virtual versions of many field trips have been developed, knowledge on the concepts of virtual and actual field trip is limited. The broader impact of this project is that virtual trips provide the only way to reach a large diversified student population. The virtual field trip and the research findings from this project should be applicable to many institutions.

**Challenges:** A considerable challenge encountered at this point is to keep up with the rapid development of information technology.

**261**

**PI:** Jennifer Wenner  
**Institution:** University of Wisc Oshkosh  
**Project Title:** Collaborative Research: Expansion of “The Math You Need, When You Need It” Through Widespread Implementation  
**Project Number:** 0920583  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** This project expands the successful pilot of mathematical modules created in The Math You Need, When You Need It. It is designed to assess the effectiveness of using modules in geoscience courses and to provide faculty with alternatives to remediating math in class or with prerequisites.

**Methods & Strategies:** We are training faculty to use the modules through summer workshops and collecting data on pre-post test gain, attitudinal surveys and scores on post module quizzes.

**Evaluation Methods & Results:** We have evaluated normalized gains and the correlation between deviation from the mean for pre-test data and the gains that students make from pre- to post test. In addition we collect attitudinal data to measure student and faculty expectancy and task value. We have found that the majority of students make gains from pre- to post test (even those who score high on the pretest). The students also see value added, responding positively to questions about the helpfulness of the modules and faculty have provided
Qualitative data suggesting they spend less time remediating math.

**Dissemination:** Modules are freely available online for any faculty to use. Faculty at approximately 50 institutions have participated in workshops. Papers published in Journal of College Science Teaching and In the Trenches. Papers in prep for Science and JGE.

**Impact:** Students have become more comfortable using math because they are given context for the mathematics. Faculty suggest that students come to class prepared for the math and can then focus on the geology. Results of this project suggest that more than 75% of the students at most institutions using these modules gain some quantitative skills through module use. Our department has been implementing it for 6 years and we have seen a large drop in time spent in the classroom teaching to the lowest common denominator.

**Challenges:** The expansion of this project has meant having to manage a large number of faculty and to deal with reams of data about the effectiveness. This has led to challenges with how to present and deal with all that data and how to deal with the variables that inevitably come with dealing with human subjects. We have formalized a protocol for how we use and deal with data - organization has been key.

### 262

**PI:** Joseph Zume  
**Institution:** Shippensburg University  
**Project Title:** Integration of Near-surface Geophysical Imaging Technology into a Geoenvironmental Science Undergraduate Curriculum.

**Project Number:** 0941777  
**Type:** Adaptation and Implementation (A&I)  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The broad goals of this project are to (1) increase undergraduate students’ interest in science through the adaptation of hands-on, field instruction that helps students visualize the connections between science and practical problem solution; (2) help students develop superior quantitative and analytical skills by incorporating high quality, inquiry-based, learning through use of geotechnology.

**Methods & Strategies:** In this project, we are a curriculum bridge approach, where we implement near-surface geophysical techniques in existing courses (e.g. hydrology, hydrogeology, physical geology, etc.) rather than develop stand-alone geophysics courses. This approach fits the inter-disciplinary nature of our geoenvironmental studies program. We reach a broader number of students this way.

**Evaluation Methods & Results:** Our evaluation is still ongoing but, overall, we have engaged the help of an external evaluation expert, who is helping us to develop assessment instruments. So far, we have surveyed 52 (Spring 2011 n=30; and Fall 2011 n=22) outgoing seniors, in the senior seminar class, on their experiences with geophysics. Preliminary results show that students are excited about the opportunity to add geophysical skills to their knowledge. Further results, assessing students learning, administered via pre-and post-tests, concept inventory, as well as the student evaluation reports are still being analyzed.

**Dissemination:** Dissemination of our project products has been in the form of conference presentations. Three undergraduate, two graduate students, and one faculty, have presented works based on this project at regional/national conferences. The project website is being populated. Also, a special session at the forthcoming Geological Society of America (GSA) annual meeting in November 2012 is planned.

**Impact:** This project has already had lots of impacts. So far, 128 students have been introduced to geophysics in four courses, over two semesters. Also, three undergraduates and two graduate students have done independent researches through this project and have presented their works and conferences. Another three graduate students are currently conducting their M.S. theses research projects through this project. Participating faculty (four) have all received training from the project. Largely, our department is attracting more graduate and undergraduate students in our region because of this project.

**Challenges:** So far, we have not encountered any major challenges in our implementation. One challenge has been the difficulty of getting blocks of time for field exposure of students outside of weekends. However, the flexibility of our students in making their weekends available for field work has helped to overcome this challenge.

### INTERDISCIPLINARY

### 263

**PI:** Bruce Alberts  
**Institution:** Science / AAAS  
**Project Title:** Science in the Classroom  
**Project Number:** 1043998  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Science in the Classroom (SitC) aims to develop a literature-based resource through which undergraduate science students can be exposed to novel research in science and to promote the integration of the scientific process into undergraduate courses.
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Methods & Strategies: Our first prototype (http://sitc.scimagdev.org/) went live in 2011. Refinements and adjustments were made in response to a review process with beta testers, our Advisory Board, and AAAS colleagues. We are working with a Web developer to complete the final version of our resource.

Evaluation Methods & Results: Teacher and student users completed a survey developed with our evaluator. Analysis showed that SitC has been well-received. While both groups varied in their responses from being neutral to strongly agreeing about the benefits of SitC, SitC had a positive influence as students’ reported increases in learning of content, interest in science, and understanding of scientific research. The learning scores looked very strong while the increase in the interest in science and the understanding of the science research scores were more modest, suggesting areas to focus as SitC continues to develop.

Dissemination: We have partnered with the College Board and they have included our prototype in the pilot study of their new Advanced Placement Biology Curriculum. When the final version of our resource is complete we will work with the marketing team at AAAS on dissemination efforts.

Impact: Initial feedback from the beta testers suggests that teachers are also learning about primary research literature through our resource. While these results do not necessarily surprise us they encourage us as teachers who are more familiar with primary research literature will be less hesitant to use it in their classrooms.

Challenges: We have actively learned about the technical interactions between Web-development protocols, and how to better situate our project for effective future interactions with the protocols that are already in place or are being planned for Science as a whole.

264
Pi: Abul Azad
Institution: Northern Illinois University
Project Title: Universal Environment for Delivering Remote-Laboratories Within the STEM Disciplines
Project Number: 0837138
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The goal of the project is to develop an environment through synergic blending of emerging Internet technology, software, computer interfacing, innovative graphical user interface, effective pedagogical designs, and assessment and evaluation schemes. The environment will be used to offer two laboratory courses within an undergraduate level electrical engineering technology program. The courses are chosen so that the validation process covers experimentation involving both the software and hardware components.

Methods & Strategies: The method and strategies for the project are: a) ability to offer laboratory courses from a range of STEM disciplines; b) students are able to design their own experiments from remote locations; c) provision of video and sound feedback to observe physical activities associated with laboratory experiments; d) integrated assessment provision; e) ease in incorporating a laboratory course with the environment; f) provision of monitoring students performance as well as their level of access to the facility.

Evaluation Methods & Results: The evaluation process will gather as much data as possible and will be used to establish knowledge in this area. The process will involve an external evaluator, students of the target laboratory courses, departmental faculty, and program industrial advisory board members. The evaluation process will involve the monitoring and assessing of all the project activities so that it can establish the level of success towards implementation of the project outcomes as presented within the proposal. The outcomes of the project are: a) design and development of the remote laboratory environment; b) design and development of graphical user interface for faculty/facilitator; c) design and development of laboratory course modules; and d) utilization of the environment for offering target laboratory courses.

Dissemination: The dissemination process involves various activities: a) faculty presentations/demonstrations at various levels, including ASEE, IEEE, and IET (Institution of Engineering and Technology); b) faculty publication in research and scientific education journals; c) maintaining a project website; and d) producing appropriate handouts for distribution among the students and other visitors.

Impact: The project allows students to design and assemble their own experiments (from a remote location) according to their knowledge level and then perform and observe (through a video and audio link and graphical user interface) the outcome to validate their idea/concept. Considering 24/7 access to the environment, students can redo any of their experiments as many times as they desire as well as perform experiments beyond the boundary of a given course. The environment will provide students with an engaging laboratory experience as well as maximize the use of laboratory equipment which is impossible to achieve through traditional style of laboratory settings. These features are also vital for teaching large numbers of students from diverse backgrounds.

Challenges: One of the main challenges of this project was the development of the proposed facility that involves the integration of software, hardware, instrumentation, and pedagogical designs. The challenge was dealt with including involving senior personnel with a background of pedagogical design and educational psychology.
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265
Pt: Cathy Bareiss
Institution: Olivet Nazarene University
Project Title: Computing Foundations for the Scientist
Project Number: 0942362
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Develop a course (and related modules) for science majors to help them understand how computing helps them with their science.

Methods & Strategies: The project involves 6 scientists from different disciplines writing modules collaboratively. The teaching involves both active learning and pair learning strategies. Work will be done this summer to enhance the online learning.

Evaluation Methods & Results: Evaluation will involve survey of current students, and previous students to find the impact of the course on their future science work and any increase in building of interdisciplinary bridges between the sciences. In addition, a comparison between students that have taken the course in their freshman/sophomore level and those that did not will be made.

Dissemination: Dissemination will involve science specific conferences, computer science education conferences, posting the modules to online repositories, and discussions (online and in person) with interested parties.

Impact: The faculty involved (from c.s., geology, chem, bio, and engineering) have developed an interdisciplinary community and learned from each other. This will only increase. All STEM faculty members are becoming more aware of grant opportunities. The interest in how computing is impacting each discipline (even outside STEM fields) is increasing. Student will be able to use computing to do more advanced science and analyze their results in other courses in more depth.

Challenges: While students do enjoy the active learning, they are still focused on 'what do I need to earn a good grade' instead of how can I learn the most from this lesson. Lessons will be reworked this summer (and language standardized) to emphasize the learning more and hold them accountable for what they learn.

266
Pt: Julie Bianchini
Institution: University of California, Santa Barbara
Project Title: Environmental Connections: Science, Technology, Society, and Education
Project Number: 0942432
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The goals of our project were to revise, implement, and research three undergraduate STEM courses. We highlighted four core themes: sustainability; connections across science, technology, society, and education; evidence-based explanations; and innovative pedagogical strategies.

Methods & Strategies: We studied the impact of the courses on both students and instructors through qualitative methods. For the students, we administered pre- and post-surveys, held focus groups, videotaped course sessions, and collected written work. For the instructors, we held interviews and obtained reflective journals.

Evaluation Methods & Results: We studied the instructors in 2010-2011. Data collected were qualitatively analyzed to document instructors' understanding of science teaching and learning, as well as to identify similarities and differences across their instructional views and practices. We found that our instructors in various disciplines (chemistry, materials, geography, and biology) used an array of reform-minded instructional strategies to teach potential teachers science. Also, all course instructors emphasized evidence as a central part of scientific practice. For 2011-2012, we plan to focus on the students' learning.

Dissemination: We presented our findings on the investigation of the instructors and their courses from the 2010-2011 academic year at the AERA conference in Vancouver on April 16, 2012. We plan to disseminate results from the 2011-2012 student data through future conference proposal submissions.

Impact: All three undergraduate courses of this project are part of CalTeach, an interdisciplinary initiative to encourage undergraduates majoring in science, engineering, and mathematics to consider careers in secondary science and mathematics teaching. Some students participating in this project have now enrolled at teacher education institutions, many of which expressed a particular interest in environmental education. In addition, one student has enrolled in a M.A. program in Environmental Education.

Challenges: As we collected and analyzed data, we realized that some of the students' and instructors' responses were not thoroughly addressing all of our four core themes. So, we met and revised the student pre- and post-surveys, instructor journal questions, and interview protocols to be in better alignment with the goals of our project. Also, the PIs and course instructors met all together infrequently. To address this, all instructors agreed on a logic model at the beginning of the project and communicated with the lead PI, evaluation coordinator, and graduate student researcher for project updates and support.
267
PI: David Blockstein
Institution: National Council for Science and the Environment
Project Title: Creating a Learning Community for Solutions to Climate Change
Project Number: 0950396
Type: Other
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To create a nationwide cyber-enabled learning community called CAMEL (Climate, Adaptation, and Mitigation e-Learning). CAMEL will engage scientists to produce a virtual toolbox of curricular resources to help teach about climate change causes, consequences, and solutions.

Methods & Strategies: We have created a web resource at www.CAMELclimatechange.org that contains hundreds of peer-reviewed encyclopedia-style articles and curricular resources about climate change, and have engaged and are educating more than 500 faculty as participants in the CAMEL community.

Evaluation Methods & Results: Evaluation uses mixed-methods, including surveys to gather formative feedback on project activities and for input regarding participant needs and assets, qualitative open-ended interviews with project leaders and participants to gather more in-depth summative feedback on the extent to which CAMEL is achieving program goals, to document multiple, varied program outcomes to beneficiaries of CAMEL, and to provide formative feedback to improve project performance and unsolicited comments from people seeking information on using CAMEL resources for education.

Dissemination: Dissemination includes online presence, word-of-mouth, multiple webinars, workshops, presentations and promotion via an e-newsletter, twitter, facebook, through extensive professional networks, organizations and associations. We regularly reach more than 10,000 educators.

Impact: Feedback from a diverse, international community of scholars across the disciplines is highly positive and indicates: ongoing use of, engagement with, and promotion of CAMEL as a climate change education resource. Nearly 500 faculty have joined the website, nearly 600 have signed up for a virtual seminar, dozens have contributed curricular resources, other climate change education projects have joined as partners and are utilizing the CAMEL site for their work. Educators are using CAMEL curricular resources in their teaching. The site has received thousands of visits.

Challenges: An unexpected challenge confronted in the CAMEL project concerned the development of the cyberinfrastructure of the website and more well-defined coordination of its multipurpose functionality. As an information resource as well as a social networking site, the CAMEL website development required greater time and specialized engineering than originally anticipated.

268
PI: David Burns
Institution: National Center for Science and Civic Engagement/Harrisburg University of Science and Technology
Project Title: Science Education for New Civic Engagements and Responsibilities (SENCER)
Project Number: 0717407
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: Described as a faculty empowerment program, SENCER improves science education by focusing on real world problems and extends the impact of this learning across the curriculum to the broader community and society; using materials, assessment instruments, and research developed in SENCER.

Methods & Strategies: SENCER offers a portfolio of faculty development workshops, national symposia, field-tested models, background papers, pedagogical materials, assessment services, and consultation. We sponsor seven regional centers, a peer-reviewed journal, a digital resource library, and other services.

Evaluation Methods & Results: Multiple strategies for assessment and evaluation have been developed and deployed. A recent analysis by the SALG PI concluded: SENCER faculty...use information gained...to make substantive revisions to their course designs and pedagogy...[and] these modifications to their courses are working: the trend line shows that scores related to pedagogical goals are increasing for SENCER faculty the learning gains made by students in SENCER courses were more likely to be long-lasting than the gains made in non-SENCER courses. A comprehensive faculty survey was also conducted in 2010.

Dissemination: To date, faculty from more than 500 colleges and universities have been active, formal participants, nearly 300 implementation sub-awards have been made, and workshops on the SENCER approach have been organized for a wide range of disciplinary and related associations.

Impact: Impacts have been substantial ranging from career impacts (e.g., ~200 participants report being granted tenure and/or promotion due in part to their SENCER work) to effects on student learning. Recent survey results demonstrate that about 8-in-10 or more strongly agreed or agreed that SENCER participation influenced instruction that increased student opportunities to experience components of [NAS/NRC] recommended pedagogical practice.

Challenges: The largest challenge we face is sustainability: how do we meet the needs of a growing and ever expanding community of practice (we have a large project but have served only about 10% of colleges and universities) in the face of limited institutional funds for staff development, travel restrictions, and the general absence of a NSF and other
government or NGO-supported platform that enables wider dissemination.

**269**
**PI:** Stephen Carroll  
**Institution:** Santa Clara University  
**Project Title:** Enhancing the Relevance and Effectiveness of Course, Program and Department Evaluation: Improving the Utility and Usability of the Student Assessment of Learning Gains Site  
**Project Number:** 0920801  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** The current SALG project aims to increase the size and vitality of the SALG-user community by developing robust analytical tools for the department site, by completing the evaluator site, and by developing interactive help and support systems for all SALG sites (instructor, department, and evaluator).

**Methods & Strategies:** We have developed a new user interface that is more flexible and easier to use, a new database that provides capacity to aggregate data much more effectively than the previous version, and a new set of help tools. In addition, we are doing more outreach and developing a user group (and possibly an advisory board).

**Evaluation Methods & Results:** We conduct user surveys, pilot tests and needs analysis regularly. We incorporate the results into the next version of the programming of the website. We also keep track of frequently asked questions and use the problems highlighted there (and consequent suggestions) to guide development of the site. We will use a professional evaluator to conduct a formal evaluation of the project next year.

**Dissemination:** The SALG website has been available to any user throughout the grant period. The SALG Development Group presents talks, workshops and other presentations on the SALG at 5-20 academic conferences per year. A small number of journal articles and one book chapter have also been published. All of these activities will continue.

**Impact:** Well over 200,000 students have taken the SALG survey. Our studies indicate that around 80% of faculty who deliver SALG surveys use that data to make changes to their pedagogy. Several studies by the SALG Development Group and others indicate that the SALG is a potent faculty development tool, prompting significant and effective pedagogical improvements. Several departments at Santa Clara University and other colleges and universities now use the SALG as their primary means to collect student feedback on faculty teaching. A small, and growing, number of Institutions of Higher Education (IHES) also use SALG in this way.

**Challenges:** We discovered in this grant cycle that the programming infrastructure and database design that were used to build the current SALG website were incapable of supporting the data aggregation features required to expand the SALG for groups - both departments and project evaluators. We have had to reallocate funds away from help systems to pay for additional programming to rebuild the databases and the main user interface.

**270**  
**PI:** Timothy Comar  
**Institution:** Benedictine University  
**Project Title:** Biocalculus: Text Development, Dialog, and Assessment  
**Project Number:** 0633232  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goals include the creation of a new biocalculus textbook, the creation a student oriented biomathematics seminar, and the assessment of the effectiveness of our biocalculus courses, materials, and seminar.

**Methods & Strategies:** The textbook development involves mathematicians and biologists Benedictine University and College of DuPage. We also have external reviewers contributing to the process. The seminar exposes a wide audience to mathematical biology.

**Evaluation Methods & Results:** Our evaluation process consists of several methods. Four external reviewers provide reviews of our textbook chapters. Feedback has been positive and has provided good constructive comments. We give common problems on the final exams for Biocalculus I and Calculus I. Results show that the students in both courses perform comparably on basic calculus tasks. Student evaluations indicate that they have learned much in the courses and have gained appreciation for the connection between biology and mathematics.

**Dissemination:** Activities include MAA PREP Workshop on biocalculus pedagogy in 2008, workshops at AMATYC, ICTCM, and the KC Tech. Expo meetings, talks at venues including MAA meetings, and a paper in PRIMUS. Papers, talks, and published textbook will follow.

**Impact:** Biocalculus has been institutionalized in our university. Now two sections of Biocalculus I are run each fall, and one section of Biocalculus II runs in the spring. Students have reported that early versions of chapters of the book are reader friendly. The seminar has reached a wide audience. Each speaker talks to over a hundred students per visit. We have signed to publish the book with Cengage and expect the textbook to be used in universities nationwide. Increasing
numbers of former Biocalculus II students are engaging in research activities.

**Challenges:** The biggest challenge we encountered was the loss of one of the co-PIs on the project, who took a position at another institution as was no longer able to work on the project. Two colleagues of the PI have joined the textbook writing component even though they are not supported by the grant.

**271**
**PI:** Edgar Corpuz  
**Institution:** University of Texas-Pan American  
**Project Title:** The Impact of Interactive Engagement Teaching Approach using PDAs as Classroom Interaction System in a Predominantly Hispanic Institution  
**Project Number:** 0737375  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goals of the project are (1) to provide a better learning environment for physics and physical science students through the implementation of an interactive engagement teaching approach using personal digital assistants (PDAs) as interaction devices, and (2) to elucidate on the implementation issues of an interactive engagement teaching approach in a predominantly Hispanic institution.

**Methods & Strategies:** An interactive engagement teaching approach using PDAs as classroom interaction devices is being implemented in several physics and physical science classes to gauge the impact of this teaching approach on students’ attitude and motivation to learn as well as on students’ conceptual understanding of physics/physical science concepts. Several faculty members have been recruited to try out the interactive teaching approach in their respective classes to investigate the implementation issues faced by different instructors (PER and non-PER faculty).

**Evaluation Methods & Results:** To gauge the effectiveness of the teaching approach, a pretest-posttest comparison group design using intact physics/physical science classes is being employed. The Colorado Learning Attitude about Science Survey (CLASS) and Science Motivation Questionnaire (SMQ) are being used as pretest and posttest to investigate students’ attitude and motivation to learn, respectively. The Force Concept Inventory (FCI) and the Conceptual Survey in Electricity and Magnetism (CSEM) are used as pretest and posttest to measure students’ conceptual understanding. Our preliminary analysis shows that the interactive teaching approach using PDAs as classroom interaction system is more effective in promoting conceptual understanding among students compared to less interactive classes (e.g. traditional lecture).

**Dissemination:** We have presented our preliminary results during local, national as well as international professional meetings of STEM organizations (e.g. UTPA Hispanic Engineering Science and Technology Week, American Association of Physics Teachers, Physics Education Research Conference, and National Association of Research in Science Teaching). A website is being managed by the PI to disseminate project activities and results.

**Impact:** The results and findings on the use of PDAs in the classroom provide a good guidance for instructors in optimizing the benefits of using web-enabled handheld devices in the teaching-learning process. In addition, the interactive engagement teaching approach may be adopted by instructors to enhance their students’ engagement in the classroom by using other web-enabled devices (e.g. smartphones, iPhones, etc.) other than the PDAs.

**Challenges:** Difficulty of recruiting other faculty members to adopt the teaching approach, especially non-PER faculty.

**272**
**PI:** Edward Coyle  
**Institution:** Georgia Institute of Technology  
**Project Title:** The VIP Program - Integrating Undergraduate Design Projects and Graduate Research  
**Project Number:** 0837225  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Develop the Vertically-Integrated Projects (VIP) Programs at Georgia Tech and Purdue: Create high-def video collaboration facilities to support multi-site VIP teams; Develop/share course modules between sites; Characterize the web of knowledge and skills created among students in vertically-integrated teams.

**Methods & Strategies:** We use hypothesis driven evaluations of the learning outcomes and characteristics of the social networks within VIP teams. Multidisciplinary growth has been fostered by direct interaction with faculty, committees and administrators across campus.

**Evaluation Methods & Results:** We use hypothesis driven evaluations of the learning outcomes and characteristics of the social networks within VIP teams. We have obtained extensive data on the learning outcomes, for both technical and professional skills in these large-scale, long-term, multidisciplinary, vertically-integrated teams. This data includes extensive and unique results on how students interact within and between teams of this type.

**Dissemination:** Since this grant was funded, VIP programs have been created at Morehouse College, the University of Strathclyde in Scotland, and National Ilan University in Taiwan. The Atlanta Girls School will form the first HS level VIP team; it will collaborate with collaborate with a VIP team at Georgia Tech.
Impact: During the term of this project, the number of students involved in VIP has grown to more than 125 per semester, the number of disciplines participating (both faculty and students) involved has grown from 5 to more than 15, and the number of colleges/universities involved has grown from 2 to 5. The student teams have successfully developed and deployed many different systems/products. Two additional course modules have been created for all VIP sites.

Challenges: Most significant challenges: Developing consensus within schools/depts., among colleges, and across the university about how participation in the VIP program should count towards students' degrees; Integrating VIP design activities with traditional senior design/capstone experience in engineering and computer science; Developing senior design criteria for VIP project teams that are highly multidisciplinary; Ensuring that each discipline that implements the VIP program adopts the full, vertically-integrated model and the curricular incentives for student to remain on teams for two or more years.

273
Pi: Lisa Dierker
Institution: Wesleyan University
Project Title: Course Curriculum and Laboratory Improvement (CCLI): An Inquiry-based, Supportive Approach to Statistical Reasoning and Application
Project Number: 0942246
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The goal is to develop a novel, interdisciplinary, supportive, project-based course that provides greater access to introductory statistics for large numbers of students. Intended outcome is providing meaningful, engaging statistical experience to students.

Methods & Strategies: Students generate testable hypotheses from provided datasets, conduct a literature review, perform data management and learn statistical software, conduct descriptive and inferential statistics, and present findings. Individual support is widely available.

Evaluation Methods & Results: Students complete quantitative ratings and qualitative comments through confidential course evaluations given at the beginning, middle, and end of each semester. Students' demographics and declared majors are also collected. At the end of the semester, 74% felt at least confident about working with data (vs. 17% at beginning); 90% would recommend the course to peers; 55% thought the course more useful than other college courses. More underrepresented minorities enrolled vs. a traditional course.

Dissemination: Instructional resources (e.g. software syntax) have been made available online. Recorded lecture clips are publicly available on YouTube. We are developing a freely available, interactive, project-based statistics textbook that can replicate the full curriculum.

Impact: Nearly 75% of students felt they were at least likely to use the research skills they learned in the class again. 80% were interested in a follow-up course (in scientific writing, data set construction, computer programming, data visualization, or advanced statistics). The course attracted higher proportions of underrepresented minorities than a traditional statistics course, and the majority of those students were very satisfied with the course.

Challenges: While individualized support was widely available outside of instructor-lead laboratory sessions, as class size increased from 60 to >100 students, the offer and availability of unlimited support was no longer adequate. Students who needed the most support showed up the least often, creating further disparities in students' experience. This semester pilots a group mentoring program in which 3-5 students meet weekly with a peer mentor/TA to work through questions. Instructors circulate among groups.

274
Pi: Marion Dresner
Institution: Portland State University
Project Title: Portland Teaching Material for Understanding Ecological Response from Climate Change in Urban Forests
Project Number: 0941763
Type: Educational Material Development Full Development (EMD-FD)
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Develop, test, and train other faculty in the use of, and disseminate the new teaching material that engages undergraduate majors in studying environmental science, environmental studies, and geography.

Address ecological processes relevant to climate variation and change through a progressive scientific inquiry approach and through visual spatial analysis.

Make learning more provocative through use of conceptual and quantitative modeling and visuals in making predictions of environmental management outcomes based on different climate change scenarios.

Improve student learning and the retention of knowledge through the use of “student active” techniques, use of visualizations such as quantitative modeling visual spatial analysis, use of conceptual modeling, and student-reflective techniques.

Methods & Strategies: Engage lower division students in environmental research that was as authentic as possible.
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through their collection of locally relevant data, and by providing opportunities to use statistical analysis and writing scientific papers using locally relevant data. Making repeated field visits over a year to the same sites to develop a heightened sense of place about the local forest. Have a continued theme through the year, that of global climate change as is experienced in their own local environments, and sequencing specific aspects of this topic over the year, to help students learn the required material in greater depth.

Evaluation Methods & Results: We studied how engaging students in an authentic research, thematic place-based approach, using an articulated curricula across terms and instructors might:

a. deepen students understanding of the material as evidenced through improvements in scores on higher order thinking skill questions.

b. Increase their ecological systems understanding as is evidenced through use of conceptual modeling

c. Increase their motivation and interest in studying environmental management; evidenced through self assessment and focus groups.

The evaluation employed a mixed-method design that included quasi-experimental assessments of students who took three courses in a sequence with the modified scientific teaching-based curriculum (treatment group), and students who took the same courses without modification and not in sequence (control).

Dissemination: We held a training workshop at the August 2012 Ecological Society of America conference for interested faculty at other universities.

Impact: The Long term retention test was comprised of 18 performance-based questions, seven self-efficacy questions and 18 content questions. Control group students scored slightly higher than treatment students on several of the lowest (Level 1) cognitive level items. However, students in the treatment group consistently out-scored students in the control group on four out of five cognitive level 2 items and all of the cognitive level 3 items.

Results from content analysis analyzing the conceptual models over the year point to a strengthening of systems thinking skills. Over the first term, a majority of students’ models began as unfocused and scattered diagrams and later showed improved ability to focus on deliberate elements of the ecosystem under study, and a heightened ability to describe specific ecological relationships. Reflective essays revealed that most students attributed their improvements in understanding over the term to their field work, a smaller group attributed their improvement in understanding to their work with modeling.

Challenges: It was difficult to change the culture at our university and have students follow a specific sequence of courses during their sophomore year.

275
PI: Thomas Foster
Institution: Southern Illinois University Edwardsville
Project Title: Regional Collaboration to Improve Science Content Courses Intended for Pre-service Elementary Teachers
Project Number: 0837417
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The goals of the project are (1) to share a science content course designed for elementary education majors with our community college partners and (2) mentor the community college (and local adjunct) instructors toward inquiry teaching.

Methods & Strategies: The mentoring of instructors follows cognitive apprenticeship with the instructors taking an immediate and active role in the course offered at SIUE before they teach it at the home institution. Furthermore, the course materials are open-source, but the underlying educational theory of the course remains intact.

Evaluation Methods & Results: Our evaluation plan has shifted as we realized the implementation issues at both the community colleges and at SIUE are more complex than instructor buy-in. Confounding the plan has been a change in the course at SIUE and many different mentoring styles implemented to guide adjunct instructors.

Dissemination: We have one peer-reviewed conference proceedings and several additional presentations. We believe the implementation issues we are now exploring with the evaluation will be of strong interest to the community.

Impact: Offering the course at other institutions relieves an enrollment bottleneck at SIUE. We anticipate that other universities and community colleges in Illinois might adopt the curriculum. We also foresee professional development opportunities for in-service elementary teachers.

Challenges: Three challenges have emerged. 1) the enrollment for the course at the community colleges is lower than expected. In part this is due to SIUE continuing to offer summer sections. 2) Oversight for the course was lost at
SIUE, therefore (a) SIUE continues to offer summer classes in spite of plans to stop and (b) the content of the course was changed to meet the staffing needs of the college. This led to 3) many new adjunct faculty teaching the course without adequate mentoring. These are issues beyond our control, but not uncommon. Our plan is to collect data and publish our findings.

**276**

**PI:** Eric Freudenthal  
**Institution:** University of Texas at El Paso  
**Project Title:** CCLI Phase 2: Increasing Attractiveness of Computing: The Design and Evaluation of Introductory Computing Coursework that Elicits Creativity  
**Project Number:** 0717877  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Eliciting understanding of and enthusiasm for computational thinking that includes an authentic experience of analytical problem solving. College freshmen initially targeted; Now extended to high school freshmen (in their Algebra 1 classes) and college-level science, engineering, and liberal arts students.

**Methods & Strategies:** Engaging activities that quickly teach a tiny interactive programming language students use to create computer graphics. Graphical output motivates exploration of basic mathematics and physics principles. Has been used as enrichment activity for math and engineering courses, and as foundation for programming courses.

**Evaluation Methods & Results:** Pre-post surveys and focus groups detected dramatic changes in student attitudes and perceived abilities in computing and mathematical problem solving. Of freshmen: 3/4 of intending STEM and liberal arts students indicated confidence and competence in computing. Increase in understanding of physics also measured.

Project initially only intended to build enthusiasm for computing through artistic creativity, but later focused on creative engagement with mathematics.

**Dissemination:** Initially focused on stand-alone programming experiences and activities were duplicated at other colleges. Now focusing on pilot studies for interventions within existing math and programming courses and development of learning modules for high school classes and professional development for teachers.

**Impact:** Dramatic increase in liberal arts students with interest and self confidence related to computation and mathematics - from essentially 0 to 75%. Anecdotal results: Dramatic improvements in high school math teachers’ attitudes towards programming. Improved pass rates in concurrently and subsequently attended math classes.

**Challenges:** Project focus changed dramatically and planned assessment activities were no longer relevant and needed complete revision.

Instructor professional development was more difficult than anticipated and required the inclusion of collaborators with relevant expertise.

**277**

**PI:** Eric Gaze  
**Institution:** Bowdoin College  
**Project Title:** Collaborative Research: Quantitative Literacy and Reasoning Assessment  
**Project Number:** 0421012  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** We have 3 main goals: 1) Develop a non-proprietary instrument for assessing Quantitative Literacy/Reasoning (QLR). 2) Pilot the instrument at 2 and 4 year schools across the country, to begin creation of national baseline of QLR abilities. 3) Create an online resource portal for QLR assessment.

**Methods & Strategies:** We are starting with a synthesized version of existing QLR instruments from Bowdoin/Colby-Sawyer/Wellesley Colleges, piloting the test to create a national baseline of QLR abilities, and working with SERC at Carleton College to build the web portal. Analysis of results from Year 1 will inform test redesign for Year 2.

**Evaluation Methods & Results:** We have 10 schools (2 and 4 year) from across the country piloting the test to 100 students each in spring 2012. We will analyze results for validity and reliability. Questions on the test will be coded for content, difficulty, and cognitive outcome. Item analysis and internal consistency will inform reliability/validity analyses and test redesign for year 2; in addition to contributing to a more detailed description of the QLR content domain. Demographic information from students will be used to track student ability levels across multiple variables. The QLRA project’s external evaluator will assist in both internal evaluation of the QLR instrument as well as evaluation of the overall project itself.
Dissemination: The QLRA project will disseminate findings through the website being constructed and hosted by SERC. Institutions from around the country will be able to request a password granting them access to the library of test items and statistics for each item. In addition project personnel will speak at local and national conferences.

Impact: The QLRA project will grant institutions from across the country access to QLR resources as they seek to assess their students and evaluate their nascent QLR programs. The QLRA Project will provide the needed assessment infrastructure and collaborative platform as the development of QLR proceeds. This will impact course development and curricular reform as institutions grapple with the educational needs of our students for the 21st century.

Challenges: We are piloting the assessment instrument spring 2012 and have had problems at some institutions with incentivizing the exam. Some participants have struggled to get 100 students to take the test.

278
PI: Edward Gehringer
Institution: North Carolina State University
Project Title: Production and Assessment of Student-Authoried Wiki Textbooks
Project Number: 0942279
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: Develop methodologies and software for facilitating the creation of large collaborative writing projects such as student-authored wiki textbooks. To disseminate the process as well as the textbooks to other instructors and institutions.

Methods & Strategies: We have a Web application to manage the process of reserving topics, peer-reviewing work, and assessing the reviews. We are using text analysis to automate the assessment of reviews. We use end-of-course surveys to assess how students viewed the process and how much they learned.

Evaluation Methods & Results: We use end-of-course surveys to assess how students viewed the process and how much they learned. In 2011, over 300 students used the system, and approximately 200 responded to surveys. About 3/4 of them believed they benefited from the feedback they received from their peers, and their peers benefited from the feedback that they gave. A similar percentage believed it was easy to use our Web app (called Expertiza) to perform the reviews. Most NCSU respondents indicated that the process of writing their wiki chapters gave them new insight into the related content.

Dissemination: The PI and co-PI have given talks at over a dozen teaching-and-learning conferences. We have built an e-mail list of over 600 instructors and instructional technologists who are interested in following the project. Our software is regularly used on four campuses.

Impact: Students consistently report that what they write gives them new insight into the topic (average about 4.2 on a scale of 5). By nearly as strong a measure (4.1) they are proud of their contributions to the textbook.

Challenges: The process of producing a textbook is different from what we expected. We built software to help instructors sequence the topics so that each topic is assigned after all of its prerequisites. However, this is not an issue, because instructors don't have the topics ready earlier anyway. Also, we expected that a student-authored wiki textbook might be an alternative to a traditional textbook. Usually, however, it is used as a supplementary text. To make it more comprehensive, we are investigating how to allow faculty to write a textbook in conjunction with student authors.

279
PI: Grandon Gill
Institution: University of South Florida
Project Title: Incorporating Complex Open Authentic Case Studies into a Capstone Course
Project Number: 1043919
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes:
1. Developing authentic case studies for an undergraduate MIS capstone course,
2. Offering the course multiple semesters,
3. Evaluating the learning outcomes of the course,
4. Developing training materials for faculty, and
5. Offering a faculty workshop on developing and facilitating discussion cases.

Methods & Strategies: a) Visiting organizations to develop IT authentic case studies. b) Evaluating the learning outcomes of the course using a variety of means. c) Publishing open access books, discussion cases and other training materials. d) Running workshops in conjunction with STEM-related interdisciplinary conferences.

Evaluation Methods & Results:
1. Have developed case studies and used them successfully in the undergraduate course (based upon student completed pre-case and post-case instruments).
2. Have determined that faculty interest exists through an oversubscribed mini-workshop conducted at IREPS 2012 in Orlando.
3. Have demonstrated adequacy of faculty instructional materials through testing them on grant personnel (who developed case studies).
4. Tested gender effects of case protagonists, 

**Dissemination:**
1. Published book 'Informing with the Case Method' (2011),
2. Offering mini-workshops at local STEM-related conferences,
3. Launching 'Journal of IT Education: Discussion Cases' through Informing Science Institute to publish cases,
4. Conference submission, and
5. Project website.

**Impact:**
1. Eleven case studies (averaging twenty single-spaced pages each) have been developed so far.
2. Course has been offered for the first time in spring 2012 (42 undergraduates). First results on learning outcomes: May 2012.
3. Faculty training workshop conducted in May 2012 (before grant start date). Outcome: Two faculty members and one doctoral student have completed developing their first case study.
4. First mini-workshop offered: March 2012. Thirty faculty signed up, 47 attended.

**Challenges:** One aspect of the grant involved determining if gender of case protagonist had impact on student perceptions of the case. The goal was to determine if developing such cases could help encourage participation by women in gender imbalanced STEM fields such as computer science. Finding sites with female protagonists proved far more difficult than sites with male protagonist. By actively seeking such sites, and networking through a group of women executives, we were able to acquire two cases that featured a woman in the central decision-making role.

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**280**

**PI:** Herman Gordon  
**Institution:** University of Arizona  
**Project Title:** Social Networking to Support Scientific Problem Solving  
**Project Number:** 0942277  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** 1. To develop and implement an online social networking environment in terms of improved problem solving.

**Methods & Strategies:** A web application called ThinkSpace was created to promote metacognitive engagement in self-regulatory learning. ThinkSpace structures student problem solving and provides access to one’s own thinking progressions as well as peer thinking. In addition, it records student thought trails for analysis by instructors and researchers. ThinkSpace was used for homework assignments within an existing course, The Art of Scientific Discovery.

**Evaluation Methods & Results:** Quantitative analysis of student thinking was made possible by mining the recorded student activity on ThinkSpace in order to generate 'Thought Trails'. The Thought Trails were characterized in terms of a complexity index. Overall, student thought trails showed that students recorded 4.6 times the minimal required effort. Students exhibited intensified engagement in other ways as well: writing a mean of 50 pages each over the semester and viewing peer work a mean 17 times per problem. Indices of metacognitive activity were also high and the levels of engagement were maintained across an entire semester course.

**Dissemination:** This work is about to be submitted for publication. A demo site is available at http://demo.thinkspace.arizona.edu. A colleague at Dartmouth College is using ThinkSpace to teach problem solving, and I'm working with colleagues at other universities to support the use of ThinkSpace in their courses.

**Impact:** Students accepted the ThinkSpace tool and, with it, exhibited sustained and reflective engagement in problem solving above and beyond anticipated external requirement or reward. In addition, they reported using structured problem solving in other classes, in research situations, and in their lives. ThinkSpace encapsulates and makes self-evident a structured problem solving pedagogy. When the Univ. of Arizona College of Medicine wanted to emphasize problem solving in medical education, ThinkSpace became a natural tool with which to articulate the pedagogy to both faculty and students.

**Challenges:** The choice of platform on which to base the technology proved to be the most significant challenge. Drupal was chosen because of the speed which it provided for development and revision. On the other hand, the speed came at the cost of a constraining standardization. In order to implement the most sensible user interface, we ended up writing custom code that amounted, in the end, to half of the project.

On another level, the need for student assessment within the technology was not anticipated. This was requested by the students, and we were able to implement it within two weeks. The assessment component within ThinkSpace enables mentors to provide individual feedback for students on their problem solving efforts.
281
PI: Nancy Hensel
Institution: New American Colleges and Universities
Project Title: Developing Undergraduate Research at Community Colleges: Tapping the Potential of All Students
Project Number: 0920083
Type: Phase 2/Type 2 - Expansion
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: Increase undergraduate research at community colleges by providing professional development workshops for faculty and administrators; developing an undergraduate research network; and developing leaders to offer future workshops on undergraduate research.

Methods & Strategies: Twelve workshops were offered involving nine teams of three faculty and one administrator. Each team developed an action plan to present on their return to campus. Facilitators were community college faculty as were the curriculum developers. All received training.

Evaluation Methods & Results: Participants completed an evaluation survey after completing the workshop. Indications are that the workshops have provided new information to participants, assisted them in developing undergraduate research programs, and assisted in developing a community college undergraduate research network. A follow-up survey will be sent to each institution to determine progress on implementation of their action plan.

Dissemination: Facilitators made presentations at the CUR and the AAC&U conferences. One of the PIs made a presentation at the AAPT. A monograph is planned that will include participant essays. Two articles were published in peer reviewed journals.

Impact: The evaluation is not complete, however, early information suggests that campuses have established or expanded their undergraduate research programs. It is expected that these programs will encourage retention of students in STEM majors, increase graduate rates, and increase transfers to four year colleges. It is anticipated that once undergraduate programs are in place in STEM disciplines, other disciplines will also begin to engage their students in undergraduate research and the above impacts will spread across the campus.

Challenges: We found out after the first workshop that we needed to revise the workshop format. We shortened the time for developing the action plan because participants completed their work more quickly than we expected. We also added topics such as how to develop an institutional review board and methods of assessing undergraduate research programs. We planned the workshops for specific regions but had many requests for teams out of the region to attend. We accommodated those requests.

282
PI: Howard Jackson
Institution: University of Cincinnati
Project Title: A Coherent Multi-disciplinary Initiative to Enhance Student Learning in STEM Courses
Project Number: 1022563
Type: Phase 2/Type 2 - Expansion
Focus: Implementing Educational Innovations

Goals & Intended Outcomes:
1. To create an effective learning environment for large introductory courses across the STEM disciplines of Biology, Chemistry, Geology, Mathematics combining Just in Time Teaching and Peer Instruction techniques.
2. Engage first-year students in participation in specially designed learning communities to improve student learning, performance and success.
3. Engage additional faculty across the disciplines in this effort.

Methods & Strategies: We have assembled a group of twelve experienced faculty members, two from each of the science disciplines, one from Sociology and one from Engineering Education to transform our large STEM introductory courses by combining the effective use of JITT and PI. We have learned from our collective interactions and the experience of others. For the first generation students, we have designed specialized Learning Communities (with the help of the Sociology faculty member) and are presently piloting these. Broad campus communication of our efforts has resulted in additional faculty participation.

Evaluation Methods & Results: Student success is measured by performance on exams and compared to classes taught by 'traditional methods.' In addition, pre and post testing using nationally normed tests, e.g. the Force Concept Inventory in Physics, is carried out both for classes using JITT and PI and those taught more traditionally. In the case of mathematical preparation, we study the effectiveness of adaptive computer software. We also survey student attitudes and run student focus groups for each of the groups. All of this data is analyzed by our evaluation partners for appropriate correlates. Finally we actively engage both department heads and faculty in supporting these initiatives.

Dissemination: We have communicated our efforts locally (campus-wide) giving presentations at the 'Best Practices in Scholarly Teaching Conference' (at UC), and 'Just in Time Teaching' (at the UC Center for the Enhancement of Teaching and Learning) as well as nationally, with presentations at the American Physics Society (Austin Texas) and 2 separate presentations at the ISSOTL-2012 (International Society of the Scholarship of Teaching and Learning) in Milwaukee, Wisconsin.
Poster Abstracts

Impact:
1. Our initiatives have demonstrated both increased student learning and increased success in introductory STEM courses.
2. Both Biology and Chemistry had genuinely significant increases compared to the traditionally taught courses.
3. Physics demonstrated significant improvement in the College Physics (algebra-based) course using an adaptive software program for mathematical preparation. The effect for General Physics was more modest.
4. In part stimulated by co-PI’s in mathematics, the math department is doing a large reorganization of their first-year large classes.
5. Our communication efforts have resulted in additional faculty participating in the initiative.

Challenges: Designing the specialized Learning Communities for first generation students proceeded in a timely fashion. However, data required, the recruiting, scholarship efforts, and the logistics of creating such a specialized Learning Community were daunting. The amount of effort was unreasonable and a new way of proceeding must be imagined. At the moment the first pilot specialized LC’s are underway and we will await the evaluation before contemplating a new approach.

283
PI: Paula Jackson
Institution: Kennesaw State University
Project Title: WIKIed Biology
Project Number: 0942085
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: Our goal is to develop a model of instruction that incorporates the use of Web 2.0 technologies to help students discriminate, assess, and assimilate the vast amount of information found on the Web to address a scientific research question. Outcomes include, improving students’ ability to use Science Inquiry to pose questions, critically evaluate sources, and communicate findings.

Methods & Strategies: We selected a suite of Web 2.0 technologies to use in the classroom. Using these tools, we facilitated students’ group work toward the following: asking questions, developing a rubric to evaluate web sources, developing an online library, developing a tagging taxonomy, enhancing their skills in collaborating with others, and producing a Web product to communicate findings.

Evaluation Methods & Results: Evaluation methods included: formative evaluations, students' self-reported learning gains, Critical Assessment of Thinking (CAT) tests, exit interviews, instructors' self-reflection, and reports from an external evaluator. Results indicate tools and activities used helped students significantly improve their ability to separate relevant from irrelevant information when solving a real world problem; scaffolding and steps helped guide students in constructing purposed research questions and structuring an investigative process; students require additional guidance in working collaboratively. Overall project results indicate progress towards an effective instructional model that uses Web 2.0 tools to support student learning in the STEM disciplines.

Dissemination: A workshop on Web 2.0 tools used for the project was presented at the International Academy of Information Management conference (December 2010), preliminary findings will be presented at the meeting of the Association of Southeastern Biologists and to faculty in the College of Science and Mathematics (April 2012). Results will also be submitted for peer review publication.

Impact: Currently, the primary impact of the project has been on students. The impact realized through the incorporation of Web 2.0 technologies has been that once they formulate a scientific question, students are improving their skill in critical discernment, organization, and use of the vast amount of information found on the World Wide Web, and are improving their ability to synthesize and transform that material into a new means of dissemination. However, the project has not yet realized its full impact. Right now we are in the implementation stage where the evaluative results of the work are being used to revise and refine our proposed model.

Challenges: Challenges included students' difficulty in formulating purposed research questions, and their need to develop strong teamwork skills. To address the first issue, we devised a workshop on asking questions and included additional scaffolding or steps towards the construction of the main research question. We also added a peer critique process for students to provide constructive feedback to classmates. Although we have implemented strategies to increase teamwork skills (e.g. peer evaluation feedback forms and a workshop on working in groups), we plan on incorporating additional measures of accountability. We will also be including a social networking tool that provides video-conferencing and allows students to track group interactions.

284
PI: Kristy Kenyon
Institution: Hobart and William Smith Colleges
Project Title: Extending CREATE Demographically and Geographically, to Test its Efficacy on Diverse Populations of Learners at Two-Year and Four-Year Institutions
Project Number: 1021443
Type: Phase 2/Type 2 - Expansion
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: This project aims to extend the C.R.E.A.T.E. strategy for demystifying/humanizing science through intensive analysis of primary literature to nationally distributed colleges and universities, through faculty development. We will test the effectiveness of C.R.E.A.T.E. in...
new cohorts of students and at the community as well as the senior college level.

**Methods & Strategies:** Through meeting presentations, publications and www.teachcreate.org, we have recruited faculty participants from 22 states, for intensive C.R.E.A.T.E training workshops (each five days in length). With an outside evaluator, we will closely follow a subset of faculty as they implement C.R.E.A.T.E. courses on their home campuses, examining student outcomes with a suite of assessment tools.

**Evaluation Methods & Results:** Workshops will be evaluated by an outside evaluator who will attend each session and provide formative (daily) as well as summative (at the end of the weeklong intensive) feedback. The PIs will examine faculty attitudes and beliefs using a Likert survey. Effectiveness of implementing faculty members C.R.E.A.T.E. teaching will be evaluated by the OE in two classroom visits, interviews, and an anonymous survey of students, including opened-ended questions. The PIs will independently evaluate implementers’ students using assessment tools for critical thinking, content integration, experimental design ability, attitudes, self-rated abilities and epistemological beliefs about science, and a post-course student assessment of learning gains.

**Dissemination:** The project is in an early stage (first workshops were in June 2012). We applied to present a workshop at the AAC&U meeting in October 2012, to discuss outcomes to date. We also will use our website (www.teachcreate.org) for dissemination of material generated from workshops.

**Impact:** We had significantly more highly qualified workshop applicants than could be accommodated, suggesting that the C.R.E.A.T.E. strategy appeals to a wide range of faculty. We anticipate that the new C.R.E.A.T.E. courses to be developed post-workshop will impact at least 10 institutions (2 and 4 year) through implementation by participants. Several workshop participants are from campuses in the midst of major curriculum revisions, and are interested in applying C.R.E.A.T.E. strategies in multiple courses and/or disciplines beyond Biology. The module bank to be developed as part of the workshop activities should facilitate this process.

**Challenges:** Some community college faculty who were accepted had to withdraw due to new assignments (e.g. necessity for teaching summer school) or the inability to get travel funds to the hosting institution (HWS Colleges). Our inability to accommodate more participants due to funding limitations has been a constraint.

**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of the project is to understand what gains are possible in student learning outcomes when an introductory material science and engineering (MSE) course is transformed from deductive practice to an inductive teaching and learning environment which includes ICT support. We have developed several MSE education applications for the iPod Touch that are designed to facilitate and support new collaborative and innovative active learning modules that target specific student learning objectives which are known to be challenging for many students in MSE courses.

We hypothesize that using these active modules in collaborative groups with data, visuals, audio, and information from the iPod Touch, will lead to improvements in student learning, engagement and retention, especially for women and other underrepresented groups in MSE programs. We are also evaluating how students use each component of the project to facilitate their own learning.

**Methods & Strategies:** In the new class format, students complete conceptually targeted problem sets each class meeting and term-long research papers in collaborative groups. Additionally, there are ample opportunities for concept questions, peer learning, case studies, and low stakes quizzes. MSE education applications for the iPod Touch have been built to support collaborative as well as peer learning and self-evaluation quizzes. In-class concept quizzes, mini-lectures, and just-in-time reading assignments are important components of the new learning environment.

**Evaluation Methods & Results:** Student progress is tracked with pre- and post-course concept questionnaires, scores from traditional exam questions, a conceptual scoring rubric for the term-long research papers, and successful course completion rates. Student focus groups have probed how the students are using each component of the project to facilitate their own learning. The results from those focus groups show that the students understand and value each component of the project, with the in-class low stakes quizzes being the most valuable from their perspective. The baseline data set for the project is for a section of the course that was taught in a primarily deductive environment with individual research projects. The second baseline type data set is for a course section inductively taught with students completing collaborative, learning objective targeted problem sets, and in-class quizzes. The next data sets are to be collected with iPod Touch support in various inductive practice configurations. Overall, there were improved student learning objective outcomes between the first two data sets. We anticipate further gains in subsequent datasets.

**Dissemination:** To date, we have presented posters and conference papers at the last two ASEE Annual Conferences. We have also presented work-in-progress papers at the last two
FIE Conferences. We have presented the work at the last two MRS Spring meetings and have one publication through MRS so far. This summer we will build the web site to accompany the project. The iPod apps will eventually be distributed freely, but are not yet ready for that step.

**Impact:** Students have been very excited by our project and have been enthusiastic participants. The students have shared their experiences with other instructors, even in departments outside our home department. Student engagement in the course is much higher. Successful completion is higher as is retention in the course. When I have presented at national conferences, outside faculty enthusiasm is high for the project. Student research papers show improvement in language usage and in the ability to connect design requirements to material property requirements; however, it is early in the project.

**Challenges:** The most challenging problem we had was with the Apple university licensing as well as their provisioning of test devices (initially only 3 months). We have successfully navigated the licensing issues now on campus and Apple has increased their provisioning of test devices. We still do not have the issues figured out for outside deployment. We moved the course to the most robust wireless access point on campus, because we were having difficulties getting all groups on the iPods at once. Student preparation in mathematics and the sciences varies from course section to course section (statistically significant) and makes data analysis difficult with regard to overall gains.

**286**  
**PI:** David Klotzkin  
**Institution:** Binghamton University  
**Project Title:** A Multidisciplinary Introduction to Microfabrication  
**Project Number:** 0942672  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations  

**Goals & Intended Outcomes:** We introduced microfabrication in a comprehensive and multidisciplinary way to the engineering and science curriculum. The outcome would be a student who appreciated microfabrication as a part of science and engineering and saw microfabrication as a legitimate subfield for a career. The student should also see microfabrication as fundamentally multidisciplinary.

**Methods & Strategies:** The basic strategy was pipeline modules (small experiments or activities) that were introduced into lower level courses, coupled with an opportunity to take a multidisciplinary capstone microfabrication course.

**Evaluation Methods & Results:** Two assessment instruments have been developed; the Microfabrication Knowledge Inventory (which includes general knowledge about microfabrication, size scales, and the like) and the Microfabrication Concept Inventory (which is more detailed and intended to measure knowledge learned from a course on microfabrication). The Knowledge Inventory has been administered to many courses both before and after pipeline activities, and preliminary results demonstrate that the pipeline activities are effectively conveying appreciation of microfabrication. The Concept Inventory will measure how well our capstone course is working.

**Dissemination:** We have presented previously at the 2010 ASEE conference, the 2010 FIE conference and at the 2011 CCLI/TUES conference. We have also submitted a paper (under review) to the 2012 FIE conference.

**Impact:** Over 500 students have been exposed to more microfabrication content, and more than 30 have taken the capstone course. We anticipate that the availability of an undergraduate “microfabrication track” will enable our students to be more competitive in that growing area. We plan on a longitudinal survey of graduated student to see how many of them ended up in microfabrication careers.

**Challenges:** The major challenge (which we hope will diminish in coming years) is attracting undergraduates to our capstone course. Currently, both years that it has been offered, the fraction of undergraduates has been less than 30%. As the course becomes better known, and students who were exposed to microfabrication content as sophomores become seniors (next year) we hope to attract more of them.

**287**  
**PI:** Mike Klymkowsky  
**Institution:** University of Colorado, Boulder  
**Project Title:** Socratic Graphs  
**Project Number:** 1043707  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** Our goal is to develop a new type of web-based, graphic-centered formative assessment that can also provide insights into how students approach difficult discipline-specific concepts and skills. Our targeted disciplines include introductory molecular biology, chemistry, and physics.

**Methods & Strategies:** We are developing activities that address core concepts, collecting student responses, analyzing those responses, and using the resulting insights to refine and revise the original activities.

**Evaluation Methods & Results:** We are using the analysis of pre-/post-activity responses (and where possible comparing them to those of students who have not used the activities) to determine where specific activities are effective at improving
student understanding, and to identify areas where activities need to either be improved or new activities developed. An example is provided by Cooper et al 2011 (http://pubs.acs.org/doi/abs/10.1021/ed900004y).

**Dissemination:** We are working to incorporate various Socratic graphs/Socratic activities with course materials we have been developing as parts of other efforts (including some currently funded by the NSF). We presented our general strategy at the Cyberlearning conference (earlier this year); see http://www.youtube.com/watch?v=0oEeniAEHau&feature=youtu.be

**Impact:** Through interactions with faculty at Clemson and Colorado, as well as involvement with the ASCB/HHMI Cell Biology Education group, we are building out activities that we plan to share with these groups. We have involved students in various early projects using our graphics approach, efforts that have led to successful, published studies: see http://www.ncbi.nlm.nih.gov/pubmed/22419590).

**Challenges:** The process requires careful consideration of, and research into student thinking, and generally things have gone smoothly.

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**288**  
**PI:** Sacha Kopp  
**Institution:** The University of Texas at Austin  
**Project Title:** Inquiry-Based Integrated Natural Sciences for Pre-Service Elementary Teachers  
**Project Number:** 0942943  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** We are further developing an inquiry-based interdisciplinary curriculum and associated teaching methodologies for a 4-semester pre-service elementary teacher education program. The intended outcomes are increased science content knowledge and self-efficacy for pre-service teachers.

**Methods & Strategies:** A team of 10 science content experts, 2 science education experts and 2 sociologists are working to create a curriculum and associated methods based on research. Focus groups involving students of the courses have been utilized along with content pre and post-assessments to advise modifications.

**Evaluation Methods & Results:** MOSART (http://www.cfa.harvard.edu/smgphp/mosart/) content exams are administered as pre and post-assessments in the 4 courses along with pre- and post-assessment attitudinal instruments. Comparison groups in non-majors courses are also administered the same battery of assessments. Gains in content knowledge range from 24-38% in the four courses for pre-service elementary teachers. Statistically significant changes in their attitude and a decrease in science anxiety have also been found in the group. Comparison groups only show gains in content knowledge of 0-10%.

**Dissemination:** Discussions of duplicating the program are underway with Texas A&M University and several smaller institutions in the state.

We are in the process of translating the pre-service curriculum into a curriculum for our in-service professional development program for elementary teachers. Currently, 150 teachers in the program serve over 11,600 students in their home schools. We plan to increase the numbers of teachers served in the next three years.

**Impact:** We are developing a growing cadre of elementary teachers in Central Texas who are prepared to teach science. Also, the curriculum writers also teach the courses and PD sessions. Their research and experiences continually lead to better decisions during the development of curricula and methods.

**Challenges:** Students are resistant to an inquiry-based curriculum because it is much more challenging. Through focus group work and research, new approaches to presenting inquiry in the classroom have been successful.

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**289**  
**PI:** James Lassoie  
**Institution:** Cornell University  
**Project Title:** Bridging Learners with Practitioners: Interdisciplinary Experiential Learning in Conversation Science Using Conservation Bridge  
**Project Number:** 0837489  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** To design and test a new approach for teaching conservation that transcends entrenched disciplinary specializations, connects students to real world case studies and practitioners, builds professional proficiencies beyond data collection techniques and abstract principles, and provides skills to work within culturally-rich, international contexts.

**Methods & Strategies:** (1) Develop a collaborative, Internet-based system for teaching environmental conservation (www.ConservationBridge.org). (2) Develop multimedia case studies for the system. (3) Test and evaluate the use of this educational system with a variety of undergraduates with diverse academic experiences and professional interests.
**Evaluation Methods & Results:** A professional evaluation firm, Edu, Inc., designed and is conducting an external evaluation using mixed methods to measure and document: (1) students' motivation, self-efficacy, and understanding of key course concepts; and (2) faculty experiences teaching with video-based, real-world case studies. Evaluation tools include Cornell course evaluations, student survey data, analysis of student essays, and in-depth interviews. Initial results indicate increased student engagement and conceptual understanding. Faculty report that teaching using video-based case studies produces superior student engagement and understanding compared to more traditional instructional approaches.

**Dissemination:** Presentations have been given at universities in the US, Canada, and China; a workshop is planned at ESA’s Annual Meeting in August 2012; and cases studies are highlighted in Conservation Magazine (CM) and ESA’s EcoEd Digital Library. An email campaign targeting 500 US faculty is underway. Ads will appear in CM throughout 2012 and 2013.

**Impact:** About 150 undergraduates have used Conservation Bridge in four different courses at Cornell over the past two years. Students have consistently reported enhanced senses of engagement, increased levels of participation, enhanced abilities to collaborate, and increased motivations to learn and complete assignments. The system is now helping to enhance student engagement in new teaching-research initiatives at Cornell. Conservation Bridge has been adopted at Beijing Normal University, and collaborations are underway to develop a multi-institutional, Chinese version that includes a supportive bi-lingual textbook. With proof of concept established, a promotional campaign is being planned.

**Challenges:** (1) Case Study Development: More time was needed than anticipated for some key case studies because of their remote locations, logistical difficulties, and needs to schedule local collaborators. A yearlong, no cost extension solved this problem, and gave us the opportunity to produce more case studies than initially planned. (2) Dissemination: Adoption to date has been primarily at Cornell and Beijing Normal University. Given feedback through evaluations, peer-reviews, and interactions with ESA and Conservation Magazine, we are poised to promote wider adoption across the US and beyond. Hence, we are now well positioned to compete for a TUES Phase 2 Expansion Grant.

**Goals & Intended Outcomes:** Facilitate the implementation of technologically-enhanced active learning by developing a cohort of faculty catalysts who will use a student-centered technology-rich studio classroom pedagogy. Assess the effectiveness of technologies to provide best practices recommendations to institutions.

**Methods & Strategies:** This project will implement a faculty development program that integrates training in active learning pedagogy within a technology-facilitated student-centered learning environment. Focal point faculty (Catalysts) will serve as nuclei for incorporation of active learning pedagogies in STEM departments.

**Evaluation Methods & Results:** Faculty adoption of active learning will be assessed using student feedback (SALG), video assessment (RTOP) and faculty-self-report. Student learning and linkage with course goals will be assessed through analysis of final exam performance and SALG. Technology will be assessed through daily usage data, room demand, and cost/maintenance balance as well as through student and faculty surveys. Training activities will be assessed by survey. Data collection from the first semester is ongoing.

**Dissemination:** We are using Merlot as an online portal for sharing of data and are also planning a variety of on-campus dissemination efforts. Expected products are general outcomes of the project as well as catalyst-developed learning activities.

**Impact:** We anticipate that this project will have substantial impacts on NMU students participating in the courses in the teaching space since active learning is relatively new to campus. Further, NMU is in the formative stages of planning a new classroom building and this project is serving as a model for the inclusion of spaces designed for active learning pedagogy. We are also hosting visits to the facility from a variety of other educators in the region, including community college and K-12 educators who are interested in applying technology in active learning.

**Challenges:** So far, this project has been on schedule and we have not encountered many difficulties. Our biggest challenge has been in working with the catalysts to encourage them to fully embrace active learning. The best approach to dealing with this has been to encourage substantial dialog among the catalysts as they discuss how active learning can be applied to different pedagogical challenges (e.g. mathematical problems vs theoretical challenges, etc.).

**290**
**PI:** Jill Leonard  
**Institution:** Northern Michigan University  
**Project Title:** Increasing Adoption of Active Learning in STEM Disciplines by Integrating a Faculty Development Program and a Technology-facilitated Learning Environment  
**Project Number:** 1043984  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Developing Faculty Expertise

**291**
**PI:** Gregory Light  
**Institution:** Northwestern University  
**Project Title:** Enhancing Critical Thinking in STEM Disciplines: A Faculty Development Model  
**Project Number:** 0942404
Goals & Intended Outcomes: To assess whether providing faculty with data on their students’ critical thinking encourages them to make changes in their teaching of critical thinking and to assess whether any changes in teaching practice lead to greater gains in critical thinking.

Methods & Strategies: We have conducted a baseline phase where we collect data on student gains on the Critical Thinking Assessment test over a semester. We will give the data to faculty, work with them to enhance their teaching of critical thinking and see if this leads to larger gains in students' critical thinking.

Evaluation Methods & Results: We have completed the baseline phase of the study and have baseline data on gains on the Critical Thinking Assessment Test. We have faculty data on the Approaches to Teaching Inventory, the Conceptions of Assessment Test. We will compare gains before and after our teaching intervention.

Dissemination: We will share critical thinking teaching activities and assessment questions on a website and will publish data in peer reviewed journals and will present data at STEM education conferences.

Impact: Our anticipated impact is that faculty will change their approaches to teaching critical thinking when they are given test data on their students' critical thinking and that their students will make greater test gains in critical thinking after faculty have been given baseline data and attend 2 workshops on teaching to enhance critical thinking.

Challenges: Having faculty give up class time to have their students complete pre and post semester/quarter Critical Thinking Assessment Tests (CAT) was challenging. We conducted testing sessions outside of class time and offered students incentives to attend such as draws for gift cards.

292
PI: Ronnie Lipschutz
Institution: University of California, Santa Cruz
Project Title: Sustainability Engineering and Ecological Design Learning Partnership (SEED-LP)
Project Number: 0837151
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: SEED-LP seeks to foster interdisciplinary and extramural collaboration teaching and undergraduate research projects directed toward addressing of societal needs. It involves two elements: (i) two specialized courses in technological literacy and social-institutional literacy, and (ii) hands-on applied sustainability labs in collaborative partnerships with agencies, organizations and businesses.

Methods & Strategies: The first element of the Learning Partnership consists of a specialized Sustainability Praxis courses in Technological & Social Science Literacy, based on new learning materials and tools and new innovative teaching methods and strategies. The second element of a SEED-LP is creation of a set of two to three hands-on laboratories for students, in collaboration with agencies, organizations and businesses involved in the policy and applied aspects of sustainability.

Evaluation Methods & Results: Evaluation methods include:
- Student participation: The number of students who enroll in and successfully complete the literacy course and complete labs.
- Faculty and student course evaluations: Periodic and final evaluations in the courses and labs.
- Collaborations: The number of successful collaborative partnerships with agencies, organizations and businesses. Collaborating partners’ evaluations of student performance in courses and labs, and evaluations of student performances in the courses and labs in which they are involved, and feedback on how the curriculum can be improved.
- Module adoption: Keeping track of expressions of interest in and adoption of the course and lab modules.


Impact: A series of about 15 sustainability labs were designed and implemented in 2009-10. These interactive labs lead students through the engineering design process while requiring them to grapple qualitatively and quantitatively with a number of key sustainability issues such as solar energy, the life cycle of biofuels and measuring carbon footprints. A technological/social science literacy syllabus has been completed, with energy as a focus. The course has not yet been taught due to lack of funding. Social science graduate students and post docs involved with SEED-LP have acquired experience in STEM curriculum development, teaching of STEM-related labs and general teaching skills, proposal writing and project management. They have also participated in writing and revising articles and in conference presentations. Several undergraduates who have moved through SEED have, after graduation from UCSC, been placed in green tech and green
finance positions. Two post-doctoral fellows (not on this grant) have moved on to tenure track faculty positions.

**Challenges:** Generating support for teaching activities from our campus.

**293**

**PI:** Marcin Lukowiak  
**Institution:** Rochester Institute of Technology  
**Project Title:** Multi-Disciplinary Applied Cryptography  
**Project Number:** 0837656  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The objective of this project is to prepare students to apply a security-oriented awareness to a broad range of hardware and software systems by developing a multi-disciplinary curriculum involving RITs Departments of Computer Engineering, Software Engineering and Computer Science. In our two new courses, students learn how to design, code, and test for security in their software as that software is being built and how to implement security-related applications, specifically, cryptographic algorithms, across both hardware and software.

**Methods & Strategies:** Our methods are focused on the development of two new courses entitled Engineering Secure Software and Hardware and Software Design for Cryptographic Applications. We also created a laboratory with field programmable gate array (FPGA) hardware boards and development stations tailored for the study of efficient software, hardware, and combined hardware-software implementations.

**Evaluation Methods & Results:** There are three distinct inputs to the evaluation of this project: (a) external industrial and academic evaluators who work in the cryptography area, (b) the PIs working on the project, and (c) the students who take the courses. In January of 2011, our industrial evaluator reviewed student surveys, course material that had been prepared, and provided us with a very positive feedback in his summary evaluation letter. We are arranging for our second evaluator, to visit us later this year to perform an on-site review. We have developed and administered several surveys for students. The results show that students are engaged with the new material, and the project has achieved its goals.

**Dissemination:** We have a paper (Developing an Applied, Security-Oriented Computing Curriculum) describing the progress on our project to this point that is accepted for presentation at and publication in the proceedings of the ASEE 2012 Annual Conference. We also are in the final stages of preparing a paper describing details of the Hardware and Software Design for Cryptographic Applications course. We are planning to prepare a paper that will discuss details of the Engineering Secure Software course and then one more paper that will describe the whole project and its outcomes.

**Impact:** The Engineering Secure Software course that is offered for the first time during the current term as a seminar, starting in fall 2012 will be a required course in the undergraduate software engineering program.

**Challenges:** One of the Co-PIs had to reduce his effort on the project due to his new responsibilities as Department Chair. As a result it was necessary to add one additional Co-PI and adjust initially proposed project schedule.

**294**

**PI:** Krishna Madhavan  
**Institution:** Purdue University  
**Project Title:** Collaborative Research: Deep Insights Anytime, Anywhere (DIA2)? Central Resource for Characterizing the TUES Portfolio through Interactive Knowledge Mining and Visualization  
**Project Number:** 1123108  
**Type:** Central Resource Project  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** Provide deep actionable insights into the TUES (and EHR) portfolio on-demand, anytime, anywhere to NSF personnel and to the community of TUES PIs, researchers, educators, and students.

**Methods & Strategies:** Our approach combines theories of community formation, user-centered design, large-scale data mining, social network analysis, and interactive visualization theories. We enable users to mine massive amounts of data and make sense of it using a highly intuitive process.

**Evaluation Methods & Results:** The evaluation plan specifically addresses formative and summative approaches for documenting, measuring, and sharing community outcomes, internal team working, and system performance. Our evaluation plan focuses on the impact of DIA2 on the TUES community.

We study the following questions: To what extent do members of the TUES community find the DIA2 suite of analytic methods and software tools usable, informative, and effective?

More specifically:

1. What are the strengths and weaknesses of DIA2?  
2. How well does it support user needs?  
3. What types of analysis has it been used for?  
4. What specific insights have emerged from DIA’s use?  
5. In what ways is DIA influencing STEM learning (theory and practice)?

**Dissemination:** DIA2 is built on a very successful prototype funded by the EEC directorate called iKNEER. We have already
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released an alpha version of the product. It is currently used in research and also for numerous tenure and promotion activities. The alpha version being tested with friendly users has over 200 heavy users of the system.

**Impact:** DIA2 is a framework for understanding and characterizing the TUES (and predecessor programs). It makes data valuable to a large community of TUES users current and future PIs, NSF program staff, and administrators at academic institutions. Since DIA2 is a knowledge portal, we have a unique opportunity to showcase the work undertaken at underserved and underprivileged institutions in new and novel ways.

**Challenges:** DIA2 sheds light on dark data. So - the biggest challenge is acquiring and cataloging data that is not very easily available. However, the project team is receiving a lot of assistance and guidance on this effort from NSF and other community stakeholders.

295

**PI:** Mark Maier

**Institution:** Glendale Community College

**Project Title:** Supporting Community College Faculty Across the STEM Disciplines

**Project Number:** 1238279

**Type:** Other

**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** The project goal is to reduce community college faculty isolation and increase community college faculty engagement with existing NSF-funded projects focused on improving undergraduate education.

**Methods & Strategies:** The grant supported a workshop (September 2012) that brought together 25 educators from across the STEM disciplines to develop materials appropriate for professional development activities at individual community colleges.

**Evaluation Methods & Results:** Evaluation will be conducted by the Science Education Resource Center (SERC) and will include statistics on project website usage, data on faculty attending workshops conducted by project participants. assessment of student learning based on materials used in workshops, and a survey of all workshop participants six months later to document projects facilitated by the project.

**Dissemination:** Participants will offer a professional development workshops for STEM faculty on their home campuses that will use the website and assess materials that were developed at this project’s workshop.

**Impact:** At present there is no single source for such information, nor is there a mechanism for interaction as will be facilitated by the project. The professional development materials will directly impact community college faculty across STEM disciplines, in their use by community college workshop participants and more widely after dissemination by all project participants.

**Challenges:** Based on our experience at the NSF-supported June 2011 Starting Point: Economics at Community Colleges workshop (http://serc.carleton.edu/econ/2yc/index.html), it was evident that even community college leaders in discipline-based professional development efforts and discipline-based professional associations were not well informed about what was occurring in other disciplines.

296

**PI:** Mitch Malachowski

**Institution:** University of San Diego

**Project Title:** Collaborative Research: Transformational Learning through Undergraduate Research: Comprehensive Support for Faculty, Institutions, State Systems and Consortia

**Project Number:** 0920286

**Type:** Phase 3/Type 3 - Comprehensive

**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The goal of the grant is to offer a series of workshops to institutions within state systems and consortia that are interested in institutionalizing undergraduate research on campuses. Teams from each school will go back to campus and assist others in seeing the potential outcomes from this approach.

**Methods & Strategies:** A series of six systems/consortia have been chosen. Four person teams from 9-23 schools come to weekend long workshops where they are exposed to issues associated with undergraduate research. We also have follow-up workshops with each system one year after the original workshop.

**Evaluation Methods & Results:** We have a series of evaluation methods. We have each team fill out a pre-workshop questionnaire to determine their needs and interests and we evaluate each workshop to determine what is having the most impact. We also will do a more comprehensive evaluation one year after each workshop. Our initial data supports the workshop model as being effective at helping teams coalesce around their goals. Virtually all respondents agreed that they would use what they learned at the workshops to take specific actions to help institutionalize undergraduate research on campus.

**Dissemination:** We have followed up our workshops with campus visits where we have given talks or run workshops. We presented a panel at the AAC&U national meeting in 2012 where we brought together folks from each system/consortia.
We have participants attend CUR events to describe their outcomes.

**Impact:** Our broad goals are to embed more undergraduate research at institutions of all types. We believe this is happening through our workshops and our initial assessment support this contention. Institutions served by the grant are seeking additional support for their undergraduate research programs. We already are getting requests for follow-up visits to individual campuses. These include working with faculty outside the disciplines covered in this grant. Because of the training we have done earlier in this project and our previous grant, we have well-prepared facilitators available to conduct these workshops.

**Challenges:** The biggest challenge is the follow-up with the individual institutions and helping them sustain the momentum they built at the workshop. We have addressed this by having facilitators remain in touch with each campus to help move the goals for undergraduate research forward and through campus visits. Sustaining relationships between schools also has been a challenging issue. We take advantage of the system/consortia offices to provide leadership and support.

297
Pi: Robert Mathieu
**Institution:** University of Wisconsin - Madison
**Project Title:** The CIRTL Network: Shaping, Connecting, and Supporting the Future National STEM Faculty
**Project Number:** 0717768
**Type:** Phase 3/Type 3 - Comprehensive
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** The goals of the CIRTL Network are to prepare a future national STEM faculty skilled in both research and teaching, create CIRTL learning communities at 6 research universities, and establish a cross-Network learning community to better prepare future faculty through the diversity of the CIRTL Network.

**Methods & Strategies:** CIRTL has developed, implemented, and evaluated strategies to prepare future faculty for careers that integrate research, teaching, and learning based on three ideas: teaching-as-research, learning communities, and learning-through-diversity. The CIRTL Network currently impacts 1500 future faculty annually.

**Evaluation Methods & Results:** Sample result: In an ongoing longitudinal study, a majority of study respondents (76%) found ways to use the knowledge and skills they gained from teaching development in their subsequent undergraduate teaching. Respondents most frequently cited delivering instruction that increases student engagement (e.g., through active learning techniques, inquiry-based learning, or the creation of learning communities within the classroom). They frequently cited assessment and course preparation and planning, especially backward design from learning goals. More findings are at www.cirtl.net/research.

**Dissemination:** More than 200 presentations, 85 papers and reports, the CIRTL Diversity Resources, and the CIRTL Guidebooks. Four bi-annual CIRTL Forums have brought the national faculty-preparation community together, most recently in October 2011. Presence in AAU, PCAST, National Academies, and House reports.

**Impact:** In a study over 5 years at the University of Wisconsin, 312 participants in 39 high-engagement experiences described steps to teaching a scientific concept. 74% discussed assessment/evaluation and half called out defining learning outcomes. 57% integrated the presence of diverse learners into their thinking about teaching, including concepts such as inclusive teaching, diverse instruction and student backgrounds. Nearly half included learning community ideas in their responses, and especially group work. 72% noted the importance of understanding learners and learning, with particular emphasis on cognition.

**Challenges:** Communication paths from coordinators of the cross-Network learning community to the future faculty on each campus are unique to each university, and broadcast e-mails from the CIRTL project directly to STEM graduate students are not permitted. Thus at least one local node in the communication path is required, sometimes leading to restricted communications. All information is posted on the web, but that communication path often is not accessed by those future faculty not already aware of the CIRTL Network.

298
Pi: George Maughan
**Institution:** Indiana State University
**Project Title:** Advancing Diagnostic Skills Training in the Undergraduate Technology and Engineering Curriculum
**Project Number:** 1140677
**Type:** Phase 1/Type 1 - Exploratory
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of this project is to develop and evaluate educational software for advancing the diagnostic skills of technology and engineering students engaged in trouble-shooting and solving technical problems.

**Methods & Strategies:** Project methods focus on developing the advanced cognition of learners by incorporating concept mapping software, rubric feedback and iterative expert solutions. Training is computer-based.

**Evaluation Methods & Results:** Evaluation plans for this project are at two levels: learner outcomes and project progress. Learner outcomes will be assessed by project investigators.
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based on an experimental, multi-level instructional treatment process. Learner data will be collected in multiple field tests. The project assessment will be conducted by an external evaluator focused on project goals and timelines. Partial data will be available January 2013.

Dissemination: Project-related dissemination will include journal manuscripts, papers and presentations at a number of academic conferences. Project participants will include an advisory board and faculty from five universities.

Impact: Anticipated impacts of this project are to improve the ability of students in engineering and technology to diagnose problems in complex technical systems. Broader impact of the project will be to provide industry, government and the military with a graduate who poses improved diagnostic skills resulting in a smarter workforce to improve our nation’s overall competitiveness.

Challenges: None.

299
PI: Charles Niederriter
Institution: Gustavus Adolphus College
Project Title: Integrating Sustainability Across and Within the Science Curriculum of Gustavus Adolphus College
Project Number: 0942235
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The primary goal of the proposed project is to improve science education at Gustavus and other colleges by taking advantage of increased student interest in energy, sustainability, and the environment. A second goal is to better prepare students and faculty to serve as resources for sustainability.

Methods & Strategies: We are developing interdisciplinary experiences relating to sustainability for students from three different groups: introductory non-science majors; science majors at the introductory and intermediate levels; and junior and senior science majors interested in energy and the environment.

Evaluation Methods & Results: Our evaluation plan focuses on progress toward our five objectives, utilizing quantitative and qualitative measures. We are combining a longitudinal statistical study of students in target courses, pre- and post-surveys to assess student learning, and a survey to assess attitudinal changes. The PIs have and continue to work with the external evaluator and the advisory panel to develop the instruments and protocols to be used for this evaluation, with the external evaluator overseeing all of the efforts.

Dissemination: We have developed a web site to act as a clearinghouse for curricular materials that have been developed and plan to link it to the National Science Digital Library. We have also presented materials at two national meetings and several regional ones.

Impact: Since the project is just in its early stages, we are just beginning to see some of its effects, including increased enrollment in science majors courses. While there have been a number of upper level students who have done sustainability related projects since the project began, it is difficult to know how many are due to our efforts. Additional data is being gathered at this time.

Challenges: The only unexpected challenge was the result of the awarding of an HHMI grant to revitalize the introductory biology and chemistry courses at Gustavus that was coincident with this project. As a result, we were dealing with a moving target in the introductory courses.

300
PI: Craig Ogilvie
Institution: Iowa State University
Project Title: Dissemination of ThinkSpace: An Online Delivery Tool of Authentic, Complex Problems to Increase Students' Problem-solving Skills
Project Number: 0941969
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: We have three objectives; 1) Establish a community of educators working on problem-solving education, 2) create the infrastructure for dissemination and community building around ThinkSpace, and 3) study the effectiveness of the community and the dissemination.

Methods & Strategies: Our change model is to build disciplinary and interdisciplinary groups of faculty who are committed to problem-solving education. We have released a fully functional open source version of ThinkSpace. New features were added to make it easier to assess (via rubrics) and provide formative feedback on student work. Especially useful is the time-saving drag-n-drop comment library.

Evaluation Methods & Results: It is important that ThinkSpace be easy to use for both students and faculty. We have contracted with ISU’s User Experience Lab who conducted focus groups and performed a quantitative user analysis. This data is being used to redesign the ThinkSpace interface as well as improve students’ navigation through complex problems. This summer and fall we plan to survey faculty users on the amount of support the ThinkSpace community has provided them as they adopt this pedagogy and the type of support they further need.
**Dissemination:** We are building communities of faculty who are engaged in problem-solving education with groups in physics, vet med, food safety, geology, teacher education, and groups starting in biology, advertising, and mechanical engineering. ThinkSpace is an incubator project in the JASIG/Sakai consortium and is the platform for the 25-university CIRTL partnership for TA training.

**Impact:** ThinkSpace is in use in approximately 20 courses with over 2000 students enrolled. Several workshops and regular in-semester training sessions have increased adoption at ISU. The dissemination at other universities has been slower. However discipline-based communities have been formed and faculty now have a set of cases they can use, making the barrier to adoption smaller. We anticipate a rapid growth as the 20 institutions currently using a predecessor tool (Pathfinder) transition to ThinkSpace.

Also by being the technology platform for the 25-university CIRTL partnership, more faculty outside of ISU will use ThinkSpace. Faculty have also shown a strong interest in the formative feedback tools. This has led to broader adoption by non-STEM faculty. For example, Jay Newell (advertising professor) states that the formative feedback in ThinkSpace changed the way he teaches.

**Challenges:**

1. New features in ThinkSpace were required as new disciplines starting using the tool. Made the tool more versatile but also more complicated to keep robustly operating. Response: We have formalized a stable release procedure and listed development priorities.
2. An increase in time pressure on faculty, is in part why they are reluctant to adopt ThinkSpace. Response: Focus on time-saving features for faculty when they use ThinkSpace.
3. Developers from other institutions have not helped, as of yet, even though ThinkSpace is an open resource. Response: Faculty first — when multiple faculty at a universities use ThinkSpace, we will then ask for some development time.

**Methods & Strategies:** We are developing exemplary materials that are classroom tested in content course --not methods courses-- at the introductory science level.

**Evaluation Methods & Results:** Classroom assessment of performance as well as custom designed instrument probing the depth of learning and understanding of computational thinking.

**Dissemination:** We are early in this new effort. Using other CCLI projects such as the National Computational Science Institute, we are bringing the same materials to other faculty.

**Impact:** We anticipate that schools of education will be encouraged to include our materials and approach for a broader audience of pre-service teachers.

**Challenges:** We have found it hard to settle on specific software and implementation requirements.

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**302**

*Pl:* Katherine Perkins  
*Institution:* University of Colorado at Boulder  
*Project Title:* Physics and Chemistry Education Technology  
*Project Number:* 0817582  
*Type:* Phase 2/Type 2 - Expansion  
*Focus:* Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The PhET Interactive Simulations project develops and tests interactive simulations (sims) for learning physics and chemistry using a research-based approach. These sims are designed to improve student learning and engagement in learning science.

**Methods & Strategies:** The sims use implicit scaffolding through their design to support productive scientist-like exploration. They emphasize the connections to every-day life, make the invisible visible, and include expert’s visual models.

**Evaluation Methods & Results:** Every sim is tested through individual student interviews. We also conduct classroom-based evaluations where we assess the impact of the use of sims on learning and engagement using content items and observation. In a recent study, we found that the type of activity guidance had a significant impact on how students explored and engaged with the simulation. We also have data showing improved student learning with simulations. Students overwhelmingly find use of PhET sims more enjoyable than traditional class work.

**Dissemination:** PhET sims are distributed through our website at http://phet.colorado.edu. They can be run online or downloaded for offline use and redistribution. They have been translated into 67 languages. We do workshops, talks, and exhibit booths at national conferences including AAPT/PERC, NSTA, ACS, and BCCE.
**Impact:** PhET sims are widely used in college (over 1200 unique .edu urls visited the PhET site) and K-12. In the past year, over 25 million PhET simulations were run online. Sims are locally used in both physics and chemistry departments across many courses. Faculty are using sims in class to communicate dynamic process and to enable classroom inquiry through ‘what-if’ student questions. Faculty also use sims in labs, recitation, and homework.

**Challenges:** The PhET project originated in physics. Our team developed expertise in simulation design which applies across the science disciplines. In expanding to new disciplines (chemistry), we needed to have access to faculty learning goals, chemistry content knowledge and expert visualizations, student ideas in chemistry, and years of teaching experience in chemistry. The formation of an advisory board staffed with experts in CER was critical.

**303**
**PI:** Jeff Phillips  
**Institution:** Loyola Marymount University  
**Project Title:** Problem-solving Examples with Narration for Students (PENS)  
**Project Number:** 1044062  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We intend to improve students problem-solving skills, in particular self-regulation skills by which students plan, monitor and adjust their solutions. We will develop instructional materials, including a searchable database of think-aloud videos, for use in chemistry, math and physics courses.

**Methods & Strategies:** We are using Livescribe smartpens to record student think-alouds, which form the basis of various in-class and out-of-class assignments. In some activities, students make their own recordings and in others they analyze the problem-solving proficiency of previously recorded solutions.

**Evaluation Methods & Results:** To directly measure problem-solving proficiency, we are developing a rubric that will be used to assess think-alouds. We are also interested in looking for secondary effects, such as improvements in conceptual understanding, which are measured with research-based concept inventories. Student views about their problem-solving learning, motivation, self-efficacy and self-regulation will be assessed with surveys. An external evaluator is following up with focus groups comprised of students who utilized the project’s instructional materials and those in courses that did not.

**Dissemination:** We are very early in the project and the dissemination has been limited to a single presentation at an AAPT meeting. We do intend on increasing the frequency of local and national presentations.

**Impact:** The instructional materials are being implemented in courses that are typically comprised of STEM majors. Therefore, the problem-solving skills that they learn will easily transfer to their other courses and professional life after graduation. In addition to improving student performance in various STEM courses, we also expect that our measures will aid departments’ assessment efforts. Beyond our campus, we can see the database of think-alouds having an impact on trainers of K12 teachers, who can use recordings to give the candidates insights into the challenges they will soon face in the classroom.

**Challenges:** The primary challenge thus far has stems from the multi-disciplinary aspect of the project. While all faculty are committed to the project, the disciplinary differences do make it difficult to find common ground as we develop materials and assessment measures. Ultimately, we believe that the diversity is a strength as it pushes each of us to question assumptions within each of our disciplines. The main method for confronting this is increasing the quantity and quality of group meetings.

**304**
**PI:** Darrell Porcello  
**Institution:** University of California, Berkeley  
**Project Title:** Infusing Emerging Nano and Green Technologies into Community College STEM Curriculum  
**Project Number:** 1044441  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Lawrence Hall of Science (LHS) and Contra Costa College (CCC) are developing a set of nano and green technologies short modules to be shared across introductory STEM courses. A career workshop will be also offered to students enrolled in the targeted courses. The project aims to build awareness of careers in emerging technologies through the infusion of hands-on experiences.

**Methods & Strategies:** LHS staff and CCC faculty, students, and staff will adapt nano and green technology inquiry-based education materials for a community college audience. These materials come from trusted sources of hands-on activities, and are frequently used within the informal science education community.

**Evaluation Methods & Results:** LHS evaluation staff interviewed CCC faculty presenting the new modules in their classes and issued pre and post surveys to students experiencing the modules. The data is still under analysis, but evaluators focused on how the modules increase content knowledge and awareness related to emerging technologies in students. The faculty interviews covered interest and comfort with including
content on emerging technologies in their courses, and their feelings about adding more interdisciplinary content in the future. This set of instruments will be deployed in each of the three semesters of the project.

**Dissemination:** The project will include posting all short modules on the LHS website, and subsequent cataloging into NSDL Pathways including: AMSER, ChemEd DL, ComPADRE, BEN, and the Engineering Pathway. CCC faculty have begun communicating project findings to regional community colleges partners.

**Impact:** At this point in the project, the largest impact has been on CCC faculty. Working together on a common project has given them a new opportunity to learn from each other and realize the interrelated nature of their individual disciplines when presenting emerging STEM research and applications. Many times during the design meetings, CCC faculty in different STEM disciplines commented how they never talk to each other about classes or content. It is anticipated the new modules and career workshops will lead to increased student interest in nano and green technology careers and programs.

**Challenges:** The project faced a serious obstacle in the form of one non-cooperative CCC faculty member. This professor monopolized the time and resources of LHS staff trying to assist faculty implementing the new modules while continuing to question the value of the project. Her presence became a distraction for the faculty committed to infusing the new nano and green technology content into their classes. LHS staff worked closely with the CCC Co-PI to convince the professor to withdraw from the project after a sub-par implementation of the module. This was a delicate situation for everyone.

**305**
**PI:** Ian Quitadamo  
**Institution:** Central Washington University  
**Project Title:** Using Community-Based Inquiry to Build Faculty Capacity and Student Critical Thinking  
**Project Number:** 1023093  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:**
1. Create and refine a faculty collaboration and development infrastructure;  
2. Build faculty expertise and capacity to teach for critical thinking;  
3. Improve student critical thinking in STEM courses; and  
4. Expand use of Community-Based Inquiry.

**Methods & Strategies:** Collaborative peer-mentoring and leverage of existing institutional infrastructure to reform faculty practice. Intensive summer institutes to support deep course revision, monthly planning meetings, embedded critical thinking assessment, and dissemination of research-supported best practices.

**Evaluation Methods & Results:** Mixed methods approach including critical thinking assessment pre- and post-tests, faculty surveys, interviews, in-class observations, course and teaching practice analysis. Results to date show some STEM courses with large gains in student critical thinking. Clear reform of faculty teaching practice in several cases. External evaluation using interviews, syllabus analysis, teaching styles inventory, other mixed methods.

**Dissemination:** Results shared across project participants. Presentations at professional meetings. Plans to disseminate at college-wide meeting. Plans to disseminate via peer-reviewed publications. Plans to collaborate with statewide STEM organization.

**Impact:** Student critical thinking has increased significantly in targeted STEM courses, although changes vary by content discipline. Faculty feedback has been strongly positive, with emphasis on long-term reform and satisfaction with new teaching approaches. Several courses not involved in project have adopted CBI.

**Challenges:** Student apathy on post-tests is an ongoing challenge. Relating need to provide quality effort to job success appears to help. Connecting need to do well to basic student needs and desires is a generally effective strategy. Recruitment of junior faculty afraid to make large changes pre-tenure. Working with chairs and supervisors will help.

**306**
**PI:** Jane Rice  
**Institution:** Michigan State University  
**Project Title:** Integrated Science through Foundational Big Ideas: Learning Modules for Pre-service Elementary Teachers  
**Project Number:** 0941820  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Our goal is for future K-8 teachers to understand that conservation of matter and energy underlies all the topics in the science curriculum and that they can use these foundational big ideas to integrate topics.

**Methods & Strategies:** We use a physical model of matter (paper clips represent atoms) and energy (paper strips represent energy units) as a tool for helping students understand foundational big ideas. We emphasize these big ideas first and foremost in every topic we study (geology, weather, ecology, physiology).

**Evaluation Methods & Results:** We evaluate students’ developing understanding of these foundational big ideas at multiple time points and in different contexts in our college
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course. We conduct clinical interviews on a sub-sample of these students. For a comparison study, we compare our students' (non-science majors) understanding of conservation of matter and energy in biological processes to that of science majors.

Dissemination: We have presented our conceptual and teaching model to a state conference of science teachers. We have presentations accepted for conferences this summer of the American Chemical Society and the Ecological Society of America. We are working on two manuscripts.

Impact: Our students report that they now have an enduring understanding of conservation of matter and energy because of the physical model of clips and strips for atoms and energy units. Several of our fellow faculty (in ecology, cell biology, geology) have asked to use our physical model and our conceptual model of foundational big ideas.

Challenges: Whenever we got unexpected results in our data (student work) we asked our students what went wrong. In other words, we asked these future teachers what was confusing or difficult about the concepts and our instructional methods. Using our students as colleagues in our research turned out to be our greatest asset. Students’ insightful comments were used to make revisions in our instructional materials for just-in-time teaching at the next class session.

307
Pi: Arlene Russell
Institution: University of California, Los Angeles
Project Title: Opening the Teaching Pipeline for STEM majors at UCLA
Project Number: 0942118
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We are developing and implementing a science education minor at UCLA that will serve STEM majors who wish to pursue teaching careers, that will have broad faculty and administrative support, and that will begin to change the culture and attitudes towards teaching as a career for our students.

Methods & Strategies: We have pursued a one-on-one involvement of faculty in the project to achieve buy-in. The introduction of discipline-based teaching practicums within the lower-division lab curricula has been seen as a win-win situation for faculty who teach the courses.

Evaluation Methods & Results:
1. A base-line survey was conducted last year to survey student attitudes towards teaching and their perception of its acceptance as a career choice among faculty;
2. Interviews with faculty will educe the motivating factors that lead to faculty support and collaboration in the minor; and
3. The number of students who pursue the minor and enter teaching credential programs.

Dissemination: The final approval of the minor by the Academic Senate on April 20, 2012, was followed with a press release in the student newspaper, and an e-mail to all STEM students. The information was in the summer catalog and was made available to incoming freshmen at Freshman Orientation.

Impact: The potential impact will be an additional 20-40 highly trained STEM teachers and an equal number of graduate students with foundation training in teaching and pedagogy.

Challenges: Drastic budget cuts to the university prevented departments from committing any resources or funding to new inter-departmental programs outside their immediate needs. A revised curriculum for the minor reduced the costs and garnered the guarantee of support by three Deans in the College of Letters and Sciences and a Dean of Engineering.

308
Pi: Kimberly Schneider
Institution: University of Central Florida
Project Title: Learning Environment and Academic Research Network (LEARN): A Model for Retention in the STEM Disciplines
Project Number: 0941980
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: This work seeks to increase retention in Science, Technology, Engineering and Mathematics (STEM) disciplines by providing first-year students an opportunity to live in a learning community together, take two courses together, and be a research apprentice in a laboratory.

Methods & Strategies: Students live in university Housing their first-year and are paired with mentors throughout the program. Students take a freshmen experience course, two semesters of 'Introduction to Research' to learn about academic research, and become a research apprentice in a laboratory.

Evaluation Methods & Results: Using direct measures (e.g., student assignments) and indirect measures (e.g., surveys, focus groups) the strengths and weaknesses of the program are being identified and adjusted through a continuous improvement process. LEARN participants will be surveyed after year 1, year 4 and year 6 and compared to a control group of students who were not in the LEARN program. Preliminary data including GPAs, retention into the second year of the first cohort as well as the strengths and weaknesses of year one of the program will be available by the conference.
Dissemination: Two presentations were completed in the fall 2011 that shared the LEARN model. Another presentation was given at the June 2011 Council on Undergraduate Research biannual meeting.

Impact: We are still early in the program but the LEARN program has increased the visibility of the national STEM retention issues at the University of Central Florida through discussion with students, faculty, staff and administration at UCF, and through conference presentations. Additionally, through this work a strong collaboration is forming between Academic Affairs and Student Affairs; two partners that often do not come together to work on STEM retention issues.

Challenges: Two unexpected challenges have been pinpointed at this stage:
1. Recruitment was low in the physical sciences and we had less first generation student apply than previously expected.
2. The focus group results after semester one were extremely positive. However, some students are reporting through their peer mentors that the work load is a bit overwhelming. This includes developing and presenting a research proposal for the 1 credit course. We have already developed a few strategies to deal with this in 2012-2013.

309
PI: Renee Schwartz
Institution: Western Michigan University
Project Title: Engaging STEM Students from the Beginning: An Interdisciplinary Approach to Teaching Introductory Biology and Chemistry
Project Number: 0941713
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Goals & Outcomes: Develop instructional materials and instructional expertise that will (1) engage students with real-world contexts relevant to biology and chemistry; (2) demonstrate the interdependence of the disciplines; and (3) promote active learning in undergraduate lab courses.

Methods & Strategies: Five lab modules were developed for the biology and chemistry laboratory courses (10 total). The lessons encourage active learning and inquiry. The graduate TAs participated in weekly professional development sessions to learn the strategies, discuss, and reflect upon their teaching experiences.

Evaluation Methods & Results: Undergraduates took a pre and post test concept assessment and attitudes survey. Results indicated the new modules were successful in enhancing undergraduates' conceptual knowledge, as compared to sections who did not participate in the new labs. Class observations, reflective writings, and interviews provided evidence of progress in TA understanding and abilities to use the active strategies. The PD was successful in helping TAs overcome barriers to engaging their students in meaningful investigations. Our model of extended PD for TAs to share with peers is supported by the findings.

Dissemination: We have presented two conference posters. We are preparing a manuscript for publication of the student outcomes related to the lab modules. The outcomes of the professional development will be presented over the next year, and we anticipate a couple of published manuscripts from that study.

Impact: Given the positive results on student achievement and attitudes, the new modules are now being taught in all the lab sections of the biology and chemistry introductory courses. The TA development portion will be continued during the next academic year to prepare and support all the graduate TAs in biology. We are planning a workshop and weekly PD sessions. Interest in the strategies has grown within the Biology and Chemistry departments. We are seeking support for further curriculum and instructional development.

Challenges: The challenges faced by the graduate TAs included their perceptions of (1) student abilities to design and conduct investigations; (2) student willingness to come prepared and stay for group discussion of findings; and (3) their own abilities to maintain a good learning environment. The weekly PD sessions focused on these challenges and provided examples of successful strategies to facilitate change. Over the course of a semester, the TAs shared concerns and successes which encouraged all to take risks for changing practice.

310
PI: Dusan Sekulic
Institution: University of Kentucky
Project Title: Systems Thinking for Sustainability
Project Number: 1044232
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Create a course template and learning materials--lesson plans, exercises, presentations, assessments -- for teaching an interdisciplinary 'systems thinking' approach to sustainability; outcomes: understanding of the topic, as well as increased ability to work in interdisciplinary teams.

Methods & Strategies: Undergraduate students (juniors) from 4 different colleges (Engineering, Business/Economics, Education, Design/Architecture) work in teams in a problem-based approach team-taught by faculty from the four colleges focused on a semester project.
**Evaluation Methods & Results:** The methods include traditional ones (graded assignments) as well as student self-assessments and of their teams and 'real time' feedback to the instructors on their grasp of the issues and techniques.

**Dissemination:** Local outreach via emails, listservs, web, UK and local newspapers. A manuscript that presents the rationale, goals and challenges in implementing the project accepted for presentation at ISSST 2012 in Boston. Established links to other universities Ohio State, Arizona State, Bern, Switzerland.

**Impact:** The first of three runs of the new course completed and data collection for analysis in progress in order to revise the course and approach for the Spring 2013 offering. The course is the first of its kind offered at UK and has had to clear a number of administrative obstacles, paving the way for other such courses. Biggest challenge so far is that students and faculty tend to comprehend and communicate within a tight disciplinary framework, which makes it difficult and uncomfortable for them to engage in interdisciplinary work.

**Challenges:** The team taught course involved additional work to create and to manage, including many more emails and meetings than a typical course; working out ways to have a single response to student inquiries and to coordinate efficient grading by several instructors is complicated; the colleges have existing procedures that don't accommodate an interdisciplinary cross-college course in terms of registration and teacher evaluations; colleges have not always cooperated with course and meeting scheduling; there are uncertainties about how to count participation in faculty DOE

**311**

**PI:** Michelle Smith

**Institution:** Eastern Kentucky University

**Project Title:** Environmental AIMS (Applied Investigations in Mathematics & Statistics): Excellence in Undergraduate Participatory Real-world Research in the Environmental Sciences

**Project Number:** 1043783

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** To determine whether a team-taught environment-centered, inquiry-based statistics lab course improve student performance and success on core content and general education learning objectives in an introductory applied statistics course, and/or student attitudes towards statistics and mathematics.

**Methods & Strategies:** We have teamed an environmental scientist with a statistician to develop and teach an inquiry-based lab that uses real-world water quality and biological data from the Appalachian Kentucky region to teach important curriculum concepts, and in which students develop an independent research poster.

**Evaluation Methods & Results:** Mastery of core content is being evaluated by comparing performance of STA 270 students in the Environmental AIMS laboratory class, a control laboratory, and no laboratory on selected identical midterm & final exam questions. Student attitudes toward mathematics and statistics are being evaluated by comparing the Environmental AIMS laboratory, control laboratory, and no laboratory students pre- and post-test scores on a 'Student Attitudes Towards Mathematics & Statistics' survey developed by an external evaluator and administered at the beginning and end of the semester.

**Dissemination:** (a) a Statistical Literacy team of 18 diverse faculty to help build links with other programs; (b) a planned faculty workshop to develop teaching teams in other disciplines modeled on the AIMS lab; (c) a regional workshop aimed at faculty from two- and four-year colleges in the Appalachian region.

**Impact:** Our aim is to fundamentally transform the way that many EKU freshmen and sophomores in general education courses encounter and experience statistics, math, and science; and also the way that statistics is taught across campus and across the Appalachian region. Initial results from participating students has been positive & pre-enrollment for Fall 2012 is triple that of Fall 2011. Also our campus-wide Statistical Literacy team are actively working on a Type-II proposal to expand the program into additional disciplines.

**Challenges:** Our goal is to present a concept in lab AFTER it is introduced in lecture but BEFORE it appears on an exam—which has been problematic when faculty are not in sync with each other on a weekly basis. We are providing each instructor with a detailed lab schedule at the beginning of the semester, and communicating with them one-on-one around exam times. We have also needed to learn to communicate effectively with each other in order to work productively together. Mutual patience and respect has gone a long way in helping us be productive, despite differences in personality and teaching style!

**312**

**PI:** Barry Stein

**Institution:** Tennessee Tech University

**Project Title:** Expanding Use of the CAT: Assessing and Improving Critical Thinking

**Project Number:** 1022789

**Type:** Phase 3/Type 3 - Comprehensive

**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** The project goals are to expand national dissemination of the Critical thinking Assessment Test (CAT) in colleges and universities across the US and in other NSF research projects to improve the assessment of critical thinking skills and efforts to improve those skills in STEM disciplines.
Methods & Strategies: The methods being used for national dissemination include: regional training workshops, webinars, conference presentations, publications, videos on public television and YouTube, a website, and social media. We conduct extensive analyses of CAT performance for each institution and NSF project.

Evaluation Methods & Results: Evaluation methods include: the number of institutions and NSF projects who are collaborating in using the CAT instrument (currently over 100 institutions are collaborating including over 25 NSF projects). Surveys are used to evaluate the effectiveness of training sessions, workshops, and presentations (satisfaction is very high) and we conduct scoring accuracy checks to evaluate the effectiveness of our training and support materials. Pre-post testing with the CAT in other NSF projects is yielding valuable information about practices that improve students’ critical thinking skills.

Dissemination: Dissemination includes: collaboration with over 100 institutions and over 25 NSF projects, 7 conference presentations, several publications, an award winning PSA video, 11 regional training workshops, and 12 webinars. Future work should double these activities and collaborations.

Impact: The project has stimulated faculty interest across the country in assessing and improving students’ critical thinking. The CAT instrument is not only an effective tool for measuring these skills, it also serves as a model for faculty who want to develop better discipline specific assessments to evaluate critical thinking. The project has also given other NSF PI’s access to a tool and training that is helping them better assess and improve their project outcomes.

Challenges: The biggest challenge we have encountered is trying to accommodate all of the institutions and NSF projects that want to use the CAT instrument. We have added training sessions in the summer and doubled the number of training sessions offered during the academic year. We are also using project revenue to support the collaboration with a larger number of NSF projects than our grant funds supported.

Goals & Intended Outcomes: Quick access to content of interest in classroom videos with 1) Index Points to switch between topics, 2) Keyword search inside videos, and 3) Text captions. Outcomes are software to support ICS (Indexed, Captioned, Searchable) videos and comprehensive assessment of their value in education.

Methods & Strategies: Index points and search database is automatically generated by video analysis. Indexing is based on identifying scene and text changes in video frames. Search is based on identifying text in video frames with OCR technology. Custom video player integrates Indexing, Captioning and Search.

Evaluation Methods & Results: The evaluation method employed is survey of classes that employ ICS Videos, which has been done for 1000s of students over six semesters. Additional evaluation is done with interviews of instructors. Key results obtained include: 1) students attach great importance to videos, on par with a textbook; 2) videos are valuable for enhancing rather than replacing classroom interaction; and 3) indexing and search greatly improve the usability of videos for learning.

Dissemination: The ICS Videos framework has been deployed at two University campuses at departments of Computer Science, Geology, and Biology and used in over 100 courses. The framework is free with some usage at other institutions. Plans are underway for ongoing maintenance of the software infrastructure.

Impact: The usage of video as an additional resource coursework has been very popular with the students. Availability of video lectures makes the instructors more ‘available’ especially for large classes. The students report that the video framework enables them to better balance education with other life challenges, e.g., jobs, care of children, and long commutes. The number and range of instructors that use videos for teaching has increased significantly over the course of the project.

Challenges: The project leverages the existing technology base (e.g. video streaming, video formats, OCR) which itself is a moving target. The project’s response has been to be quick to adopt new technologies when they offer an advantage. For example, the first generation ICS video player was a desktop player based on Java while the current one is a Flash based player that can be embedded in a browser. The default video encoding has moved from Quicktime to H264.

313
Pi: Jaspal Subhlok
Institution: University of Houston
Project Title: Collaborative Research: Tablet PC-Based Indexed Captioned Searchable Videos for STEM Coursework
Project Number: 0817558
Type: Phase 2/Type 2 - Expansion
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: We are targeting three primary goals, utilizing new instrumentation including a portable X-ray fluorescence spectrometer (XRF) and an inductively-coupled
plasma optical emissions spectrometer (ICP):

Goal 1: To improve both science and non-science majors' understanding and appreciation of the scientific method by providing engaging, interdisciplinary opportunities.

Goal 2: To improve the depth of understanding and application of elemental analysis methods and spectroscopies in college students and all curricular levels.

Goal 3: To develop students' appreciation and recognition of the inherent interdisciplinary nature of many scientific problems while fostering multidisciplinary faculty interactions to form the foundation for future collaborations.

Methods & Strategies: We are attempting to achieve the above-listed goals by:

1. Initiating new, interdisciplinary undergraduate research opportunities;
2. Collaborating with external community organizations as well as between STEM and non-STEM disciplines for both curricular improvements and research projects; and
3. Initiating new laboratory activities across the full spectrum of the undergraduate curriculum (from introductory through senior capstone experiences), which integrate XRF and/or ICP use with improvement of students' understanding of elemental analysis and the scientific process.

Evaluation Methods & Results: In addition to standard student assessments, including but not limited to lab reports, questions on quizzes and exams, anonymous pre- and post-activity online surveys, classroom discussions in the context of grant-related topics, and post-term comments on student evaluations, we have also hired an external evaluator for independent program assessment. At this point, we have received a formative assessment report from our evaluator, which focused on our grant activities in the context of our stated program goals. He had access to most of the above-stated assessments, and he also interviewed all faculty and staff involved in the project as well as undergraduates who have used the analytical tools in their own research. In brief, he found that all goals were being met, in some cases beyond what was originally proposed, but that greater communication between students at different levels (i.e., introductory vs. upper level) and with different academic backgrounds (e.g., science vs. non-science) could further improve the effectiveness of activities.

Dissemination: We have presented the results of undergraduate research as well as interdisciplinary laboratory projects across a range of media and forums. These include: a local television story; stories in the Trinitonian, the student newspaper; a story in Trinity's alumni magazine; two stories on Trinity's website; a significant entry in a blog for art conservationists; two stories in the San Antonio Express News; and a wide range of conference presentations. Our next significant step will be to submit manuscripts for journal publication.

Impact: The project has been far more successful than we originally anticipated. A wide range of faculty across both STEM and non-STEM departments have been involved, student learning has been directly impacted by significant curricular initiatives (including a term-long chemistry-geosciences cross-class project), and interdisciplinary undergraduate research has involved off-campus entities such as the Alamo, the San Antonio Museum of Art, the McNay Art Museum, and a local art studio. This project led to a new proposal to the Keck Foundation that could significant affect most STEM disciplines, based on new instrumentation and curricular innovations.

Challenges: We did not anticipate the regulatory issues we've experienced with the XRF. The state-level radiation safety regulations have limited student use of the instrument. The cost of attaining licenses is not trivial, and only licensed users are permitted to activate the X-ray tube. Therefore, with the exception of one student researcher, no undergraduates are permitted to operate the instrument itself. While not insurmountable, this barrier does affect the type of activities that we can perform with the instrument.

315
PI: Mary Anne Sydlik
Institution: Western Michigan University
Project Title: Collaborative Research: Automated Analysis of Constructed Response Concept Inventories to Reveal Student Thinking: Forging a National Network for Innovative Assessment Methods
Project Number: 1022747
Type: Phase 2/Type 2 - Expansion
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: The overall goal of this project is to develop constructed response versions of established conceptual assessment inventories and to create computer automated lexical analysis resources to be made broadly available to instructors and researchers as a tool for revealing students’ thinking.

Methods & Strategies: An iterative approach is used. Items are created to identify disciplinary constructs, then lexical analysis software extracts key terms and scientific concepts from written student responses. These data are used as variables for statistical classification techniques to predict expert ratings of responses.

Evaluation Methods & Results: As the external evaluator I attend (remotely) most weekly PI/Co-PI meetings; attended two annual PI/Co-PI meetings, where I collected observational data and administered a post-meeting survey; and have written meeting reports, two annual reports, and am analyzing interviews conducted Nov-Dec 2011, with team members. I also provide formative evaluation feedback to the main PI as well as to the project team. The project team has made good progress.
moving toward over-all project goals and have been responsive to formative evaluation feedback.

**Dissemination:** Four peer reviewed articles have been published, and another is in revision. Team members have presented peer-reviewed conference papers, many poster sessions, and talks at both our own as well as other institutions. The project web site (http://aacr.crcstl.msu.edu) has downloadable resources.

**Impact:** We have extended and deepened collaborations among science education researchers at MSU, OSU CU-Boulder, U of Maine and UGA to leverage our respective research on constructed responses assessments that reveal student thinking in STEM disciplines. We have adapted existing concept inventories and diagnostic question clusters to constructed response formats and are working on validating these instruments. We are developing libraries to automate the analysis of students' written responses along with statistical models that predict expert scoring based on extracted linguistic concepts.

**Challenges:** Our project is very interdisciplinary, including biologists, geologists, educational psychologists, science educators, linguists and evaluation; with personnel ranging from faculty, post docs, graduate and undergraduate students. We are spread across multiple institutions and time zones. While we had previous experience working in interdisciplinary teams, coordinating meetings and the range of expertise has been challenging. We have worked extensively with our evaluator to improve our communications and optimize our meetings. We also instituted more one-on-one work across the team.

316

**PI:** Donald Takehara

**Institution:** Taylor University

**Project Title:** High Altitude Ballooning in Undergraduate STEM Curriculum: Preparing for Widespread Implementation

**Project Number:** 1047557

**Type:** Phase 2/Type 2 - Expansion

**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:**
1. Build core group of universities implementing ballooning into curriculum
2. Determine feasibility of ballooning in curriculum for Education Majors
3. Determine best practices for marketing and training new universities
4. Conduct longitudinal assessment of student learning in undergrad courses

**Methods & Strategies:**
1. Develop annual Conference, joint university projects & competition
2. Develop K12 curriculum in Education classes & test in local schools
3. Develop on-line training, regional workshops, university mentoring
4. Pre and post surveys of student learning continued from previous grant

**Evaluation Methods & Results:**
1. Annual Academic High Altitude Conf.- 50 attending, 20 papers at 2011
2. Website for training - 100% traffic increase between 2011-2013
3. Workshops - 50% of attendees implementing in courses
4. Education classes - Improve student Pedagogical Knowledge of inquiry teaching as measured by Pedagogy of Science Inquiry Teaching Test (POSITT)
5. Learning assessment showing practical significance in multiple student learning categories routinely
6. University competition - 12 competing by 2013

**Dissemination:**
1. Annual Academic High Altitude Conference
2. Core universities mentoring and collaborating with other universities

**Impact:**
1. Faculty at 10 universities are collaborating on the development of experiments
2. Practically significant student learning outcomes are occurring in courses
3. Taylor University has committed to continued implementation in gen ed science and engineering classes as well as continuing to support STEM initiatives
4. Preserve teachers are developing K12 curriculum using ballooning
5. Informational webinars to universities are regularly occurring
6. Workshop at the Small Sat Conference scheduled for August 2012

**Challenges:**
1. Attendance at workshops is a challenge due to the economy and lack of knowledge on ballooning (as determined by marketing survey). We are going to webinars and workshops at existing conferences.
2. Participation in University Competition is low. As a result, we are looking at it being more of a collaborative effort with the core ballooning universities.
3. It has been difficult getting universities to complete the pre and post surveys for the longitudinal study. We are working directly with the universities on completing the surveys.
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317

PI: Joseph Tront
Institution: Virginia Tech
Project Title: Toward Improving Dissemination & Building Community for CCLI Innovations
Project Number: 093851
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The goal of the project is to understand how to foster better dissemination of CCLI/TUES-developed educational innovations. Once this question is explored and better understood, the project will present to the community its findings and begin to work with those who want to employ newly identified promising mechanisms.

Methods & Strategies: We began by surveying PIs who previously received CCLI grants from 1999 to 2010 to identify commonly used dissemination techniques and identify best practices. Next we convened a panel of 35 PIs and dissemination practitioners, along with 10 NSF PDs, for a two day discussion of current and future dissemination practices and how they can be tuned to the types of projects CCLI engenders.

Evaluation Methods & Results: The project in itself is an evaluation of the processes used by other types of CCLI projects. Results indicate that the most frequently used methods of dissemination do not lead to desired outcomes. Several methods to improve access to resources and the adoption of these resources by other faculty were identified. We also obtained feedback on how this project operated and the results obtained generated in the panel discussions and the surveys, from outside assessment experts. All evaluations of the project were quite positive.

Dissemination: The results have included several papers and presentations, as well as a workshop describing the findings and the recommendations for dissemination improvement.

Impact: Several pieces of anecdotal information were gleaned from conversations at the paper presentations related to how other TUES planned to use some of the dissemination techniques we brought to their attention. We also used the results of this project to write a successful proposal to experiment with web-based dissemination techniques called Idealams.

Challenges: None.

318

PI: Mark Tuominen
Institution: University of Massachusetts Amherst
Project Title: Development and Porting of iCons III: Student-Designed Labs in Renewable Energy
Project Number: 1140805

Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Develop laboratory curricula, used at both the University of Massachusetts (UMass) and Holyoke Community College (HCC), for courses that focus on renewable energy (RE). We will build and assess laboratory curricula that produce the kind of multidisciplinary, collaborative problem-solvers needed by the emerging RE industry. The project also assesses pedagogical questions associated with interdisciplinary, team-based, student-led research laboratory learning.

Methods & Strategies: This is problem-based lab science focused on renewable energy, multidisciplinary student teams, student-driven lab design, and near-peer mentoring to provide academic support. Both HCC and UMass RE lab courses will begin with a Boot Camp consisting of modules that train student teams to safely use lab equipment relevant for topics including solar energy, biofuels, and energy conversion and efficiency. The HCC/UMass team will develop and share digital videos to facilitate training in proper equipment use. Following Boot Camp, student teams engage in two student-designed investigations (Unit Projects), wherein teams pose questions, develop hypotheses, design experiments, collect and interpret data, and submit final reports, all with scaffolding assistance from lab instructors and near-peer mentors.

Evaluation Methods & Results: We use direct- and indirect-, formative- and summative evidence to determine how well the RE labs reach our educational objectives. An important feature of our evaluation plan involves direct assessments of student performance, applied at the following key touch points during the RE labs: 1) A pre-assessment, prior to the start of the Boot Camp, to assess students’ recall of prior learning and their performance on a team-based activity (in the 4-year iCons program); 2) Assessments during and at the end of Boot Camp to evaluate students’ understanding and proper use of experimental techniques and laboratory equipment; 3) Assessments during and at the end of Unit Project 1 to evaluate student performance on key learning goals; and 4) Assessments during and at the end of Unit Project 2, monitoring students further development of key skills.

Dissemination: (Project is new in 2012 - no completed dissemination activities to date)

Impact: (Project is new in 2012). Student impact on attitudes, knowledge, and skills required for leadership and integrative teamwork in renewable energy. Skills in teamwork, experimental design, communication and analysis. Project will have impacts on the faculty involved in curricular development in mentoring/guiding student-led learning and the interdisciplinary learning environment. The project is also an integral part of iCons (Integrated Concentration in science) -- a new concentration available to science majors in which problem
solving of real-world challenges (energy, medicine, etc) and scientific leadership is emphasized.

**Challenges:** *(Project is new in 2012)* We foresee a challenge in introducing integrated team-based project management best practices alongside the scientific principles and laboratory methods. We also foresee a contrast between this pedagogy, which emphasizes the development of 'student ownership of learning', and traditional courses -- the outcomes of the student work are less certain than that of a fully prescriptive laboratory course. However, we expect that the scaffolded approach (boot camp/unit project 1/unit project 2) can address this issue.

### 319

**PI:** Mark Urban-Lurain  
**Institution:** Michigan State University  
**Project Title:** Collaborative Research: Automated Analysis of Constructed Response Concept Inventories to Reveal Student Thinking: Forging a National Network for Innovative Assessment Methods  
**Project Number:** 1022653  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** Develop constructed response versions of established conceptual assessment inventories and create computer automated lexical analysis resources to automate their analysis. This combination will be made broadly available to instructors and researchers as a tool for revealing students’ thinking.

**Methods & Strategies:** We use an iterative approach. We use lexical analysis software to extract key terms and scientific concepts from the students' written responses. These terms and concepts are used as variables for statistical classification techniques to predict expert ratings of student responses.

**Evaluation Methods & Results:** We have an external project evaluator, who (1) attends (remotely) most weekly PI/Co-PI meetings; (2) attended the 2010 and 2012 annual PI/Co-PI meetings; (3) has written meeting reports, two annual reports, and is analyzing interviews conducted Nov-Dec 2011 with staff; and (4) provides frequent formative evaluation feedback to the main PI as well as to the project team as a whole. The evaluator believes the members of the project team have both made good progress moving toward over-all project goals and have been responsive to formative evaluation suggestions for improvement.

**Dissemination:** Published four peer reviewed articles and have one in revision; presented several peer-reviewed conference papers, many poster sessions and talks at our respective institutions and other institutions. We have a project web site that has our publications and downloadable resources from the project.

**Impact:** We have extended collaborations among science education researchers to leverage our respective research on constructed responses assessments that reveal student thinking in STEM disciplines. We are validating instruments by developing and applying scoring rubrics with multiple expert raters on large samples of student responses across our institutions. We are developing libraries to automate the analysis of students' written responses and creating, testing and validating statistical models that predict expert scoring based on extracted linguistic concepts.

**Challenges:** While we had previous experience working in interdisciplinary teams, coordinating meetings (using video conferencing) and the range of expertise has been challenging. We have worked extensively with our evaluator to improve our communications and optimize our meetings. We have also instituted more one-on-one work across the team (e.g., having our post-docs meet with different faculty to assist with data analysis and software use.)

### 320

**PI:** Elsa Villa  
**Institution:** University of Texas-El Paso  
**Project Title:** Building Support Structures for Full Adoption of the Affinity Research Group Model  
**Project Number:** 920300  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** (1) Create a self-sustaining support structure through which ARG adopters can learn, practice, and critically reflect on ARG core components; (2) improve the ARG model by reinforcing (addressing) the factors that enable (hinder) the adoption of the ARG model at geographically diverse institutions; and (3) determine the impact and success of ARG adoption.

**Methods & Strategies:** (1) Establish an ARG professional development program; (2) implement a support structure; (3) evaluate the effectiveness of the ARG professional development program; (4) investigate the role of specific individual and contextual factors; and (5) collect demographic and experiential data.

**Evaluation Methods & Results:** Evaluators used mixed methods using electronic pre-post-workshop surveys, participant observation during workshops, and informal conversations. Data analysis generated the following findings: ARG adopters have extensive prior research mentoring experience; research facilitates students’ development as professionals; ARG adopters have ‘arg-ified’ their practices; time is the most common challenge to adoption; strong beliefs in the ARG model remain steady; adopters are now fairly confident in their implementation of the ARG model; and adopters have sharpened their understanding of the nuances of the model.
Poster Abstracts

Dissemination: The website, http://cahsi.cs.utep.edu/PRACTICES/ARG/Philosophy/tabid/113/Default.aspx, has general information about the model. It has been adopted by the NSF-funded CAHSL project. A handbook is available at Amazon and IEEE Computer Society. It is highlighted as a promising practice in the National Centre for Women in Informational Technology (NCWIT).

Impact: Components of the ARG model have been transferred to a research course at the University of Puerto Rico-Mayaguez and is featured by NCWIT as a promising practice.

Challenges: While some aspects of the model were easily implemented by Adopters, some Adopters remain uncertain about the two elements, group processing and defining a core purpose. These two elements will be emphasized in the Advanced workshop for Adopters.

321

PI: Travis Wagner
Institution: University of Southern Maine
Project Title: Applied Energy Education at the University of Southern Maine
Project Number: 941778
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To develop an applied energy education curriculum for undergraduates. The project will train majors, non-majors, and non-matriculated students in energy efficiency, renewable energy production technologies, and training in lifecycle assessment for structure level energy analysis and management.

Methods & Strategies: We have obtained and are modifying a typical Maine home on campus to be used as a learning and research laboratory for students in the applied energy curriculum. By using a real house, through active learning, students will gain practical and applied skills to understand energy principles and conservation.

Evaluation Methods & Results: We do not yet have results, but are in the process of obtaining them. We are using SALG to measure the learning gains in individual courses and the progress toward the curriculum. A key component of the program is the creation of an internship program. Results of the internships and applying SALG to students who complete the internship will also be part of the evaluation. We have not yet obtained sufficient results.

Dissemination: Currently our dissemination is limited to local and regional mass media. We have created an external advisory board that will help further with public dissemination. As we collect more data, we will seek academic dissemination. We will be presenting at the ACS conference in August.

Impact: Through the creation of an external advisory board composed of area and state public and private officials, we have increased the visibility of the curriculum while ensuring the post-NSF funding sustainability of the project. In addition, the ability to obtain an actual house to be used as a lab and classroom allows us to conduct active and applied learning under real conditions. Thus, an important impact is that our students will become more knowledgeable about the applications and limitations of energy conservation and sustainability in buildings in Maine—a highly oil-dependent state.

Challenges: The primary unexpected challenge is that while we began the implementation of the project, the overall economic downturn put unexpected financial strains on the university. Key to our success was having a dedicated energy instructor. This finally occurred by demonstrating and highlighting a demand by students and a need in the workforce. This part was assisted by the creation of an external advisory board.

322

PI: Frank Wattenberg
Institution: United States Military Academy
Project Title: DIYModeling -- Do It Yourself Modeling and Simulation for STEM Learning
Project Number: 0919264
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To improve students understanding of the knowledge, skills, and perspectives of the STEM disciplines and their ability to bring them to bear on difficult and consequential problems. We are particularly focused on their ability to use mathematical modeling based on science.

Methods & Strategies: We have developed software that enables students to create game quality immersive 3D simulations focusing their attention on the mathematics and science without being distracted by the minutiae of computer programming. Students check their work by analyzing their simulations.

Evaluation Methods & Results: We use focus groups, interviews, and observations of students working with the software in addition to student performance on graded homework, exams, and written projects. Students find the software and associated curriculum materials engaging and spend significant time on task. They are able to discuss their work both orally and in written papers. We expect to have additional results by the end of the current semester.

Dissemination: We have given many talks at national meetings in physics and mathematics. We just conducted a minicourse at the International Conference on Technology in Collegiate Mathematics. We plan workshop workshops as part of the MAA PREP program in June 2012.
Impact: This project has dramatically affected the way we teach and our students learn. Students check their work not by looking up answers in the back of the book but rather by seeing the results of their work in their simulations. In addition, we are using simulations we have created as interactive homework and as virtual labs, often complemented hands-on labs. Our project has run into substantial challenges -- for example, many students have weak 3D understanding -- and we have developed curriculum materials addressing those challenges.

Challenges: In contrast to other software our software requires students to supply the mathematics and the science. For example, other software often relies on physics engines. Thus, our approach is scientifically demanding. We have developed curriculum materials that build the necessary scaffolding. As one example, students develop the ability to use cameras (choose viewpoints) in 3D simulations by first using their digital cameras to reproduce a set of photographs and by using mathematics to guide unmanned aerial vehicles in simulated reconnaissance missions.

PI: Kathy Williams
Institution: San Diego State University
Project Title: NSF DUE/TUES: Project PLURIS Purposeful Learning in Undergraduate Research and Independent Studies
Project Number: 1044460
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: PLURIS aims to improve the cost-effectiveness and academic consistency and auditability of undergraduate STEM independent study and research activities, so these activities can be offered to larger numbers and diversities of students, by designing research experiences that clarify purposeful learning.

Methods & Strategies: Help faculty and students: elucidate opportunities for learning in host project and recruit students; align individual student learning agendas with goals of supervising faculty; clarify intended student learning outcomes; use clear assessment techniques to monitor and document actual learning outcomes.

Evaluation Methods & Results: Plans: Rapid prototyping that benefits from brisk testing of concept designs and prototypes, good flows of formative evaluation data, and generous access to potential users, and actual testers; produces written reflections from students, to be triangulated with survey and focus group results. Faculty who agree to test prototype PLURIS process and materials with students, along with administrators and other stakeholders, are evaluating the prototype as it is built and offer recommendations for improvement. Postdoc/PhD student will help develop questionnaires and survey materials for this evaluation.

Dissemination: This project involves developing and testing a prototype system using a community-based co-design strategy, which itself provides dissemination. We are already further disseminating these concepts in professional presentations and will continue to do so through articles and conference papers.

Impact: Expected impacts include 1) providing a model to enhance current science education efforts within and beyond the university, 2) forming a collaboration among scientists, educators, and educational technology professionals to further develop the science education expertise of STEM faculty, and 3) encouraging undergraduate, postdoctoral, and faculty researchers to think metacognitively about research experiences and learning in general. We are seeing all three happen, even in the project’s early stages, across departments and colleges at our university.

Challenges: The main challenges we face are not completely unexpected, and relate to the increasing pressures on faculty and the university structure due to economic issues facing our university. Fortunately this project addresses ways to increase both effectiveness and efficiency in education and research activities for students and faculty.

PI: Jeannette Yen
Institution: Georgia Tech
Project Title: Biologically Inspired Design: A Novel Interdisciplinary Biology-engineering Curriculum
Project Number: 1022778
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Creating Learning Materials and Teaching Strategies: Biologically inspired design represents a powerful and logical bridge to multidisciplinary education. Biologists and other scientists implicitly understand general principles relevant to function and design. Biologists and engineers each face the problem of identifying design criteria, yet each approaches the problem from a unique perspective. Through the adoption of a common language and a merging of perspectives, students will exemplify the interdisciplinary process in overcoming the barriers that often inhibit true multidisciplinary collaborations. Through problem solving exercises, students learn how to use the design process to create biologically-based systems or prototypes that solve specific engineering problems and test hypothesized functions of biological properties.

Methods & Strategies: From classroom observations, in situ cognitive studies, experiments conducted in class, and detailed analysis of student design products, we focus on five learning objectives to implement education innovation and to contribute to Research on Undergraduate STEM Education: (1) novel techniques for creative design, (2) interdisciplinary
communication skills, (3) knowledge about domains outside of their core training, (4) a uniquely interdisciplinary design process, and (5) how to apply existing technical knowledge to a new discipline. We developed the following course components to meet the five key learning objectives: BID Lectures; Design Lectures; Found object exercises; Quantitative assessments; Analogy exercises; Research assignments; Interdisciplinary Collaboration, Mentorship; Idea Journals and Reflections.

**Evaluation Methods & Results:** To establish assessment metrics to measure design education outcomes, and to empirically validate the success of the BID education platform, we are conducting evaluations to validate the success of our key themes: creativity, communication, cross-domain knowledge transfer, and design skills. We are assessing student differences as functions of their backgrounds and the cognitive approaches and, for group projects, as a function of the diversity of backgrounds. A post-doc versed in education and experimental design is developing specific instrumentation, collection, and analysis methods for these metrics.

Our initial results indicate that BID improves both engineering and biological understanding and moreover is a catalyst for innovation, encouraging engineers to embrace biology as a source of inspiration and biologists to use engineering techniques as new evaluative methods for biological systems.

**Dissemination:** For Scope Expansion, we develop a 3-part series of courses to create a focal concentration in biologically inspired design, culminating in a senior capstone design experience. This 3 part series would form the basis for a minor or certificate program in BID that may provide models that can be exported to other institutions with similar goals.

**Impact:** We find that students in our course develop a strong appreciation for interdisciplinary research and the limits of traditional disciplinary training. Biologists enhance their training through increased understanding of quantitative approaches and engineers become more attentive to biology and environmental responsibility. Our course has attracted interest in biologically-inspired design by other faculty, which has led to a variety of collaborative and project based teaching opportunities.

These include collaborative teaching between biology and architecture, mechanical engineering, materials science, and industrial design. Several efforts involve industrial collaborations and are focused on addressing societally important problems in sustainability. We also have used material and approaches from our efforts for informal science education by partnering with local museums, zoos and aquaria.

**Challenges:** Biologists do not often see their activities as problem solving approaches and engaging them is more difficult than expected. Achieving a balance between content and process instruction also was more difficult then expected; although the process is essential, the lack of sufficient engineering or biology depth results in facile and superficial applications that do not address core learning goals. As much of the course is project based, we are striving to develop better in class assessment and feedback mechanisms. Much depends on the willingness of outside faculty, who are experts in certain fields, to act as mentors. However, institutional barriers often make it counter-productive for faculty to be engaged in this way. Additionally, guest lecturers sometimes have a difficult time understanding the premise of the course and the need to present their material in a framework consistent with course pedagogical methods and goals. To prevent inconsistencies it sometimes is easier to use their content rather than have them give the lesson, and we have had to choose guest lecturers carefully.

**325**

**Pi:** Huseyin Yuce

**Institution:** New York City College of Technology

**Project Title:** Brooklyn Waterfront 2050

**Project Number:** 0942720

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The goal of the project is to create Environmental Science I and II courses in order to provide students the scientific principles, concepts, and methodologies required to understand the inter-relationships of the natural world, to identify and analyze environmental problems of Brooklyn Waterfront both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving or preventing them.

**Methods & Strategies:** Courses introduce foundational concepts in STEM disciplines in a setting of the local environment (Brooklyn Waterfront) beyond the classroom and laboratory. The text of the course is a collection of modules prepared by faculty involved in the project. The modules are designed to follow project and inquiry based approaches with visualization. Each module contains environmental issues of Brooklyn Waterfront.

**Evaluation Methods & Results:** Educatively, outcomes-based, and Context, Input, Process, Product (CIPP) evaluation methods are being used in the project. We are collecting data from a pilot course that is running currently. The actual course will be running on Fall 2012.

**Dissemination:** As part of the dissemination process, we will be holding a public event to present the student projects to the community and to the college. We plan to run the courses every academic year as part of the general education science requirement.
Impact: The impacts on students are still under evaluation. Faculty development workshops assist faculty in implementing the pedagogy. So far we have had 4 workshops and plan to have 3 more. Besides co-PIs and personal roles of the project, the workshops draw faculty members from various disciplines within the college. We also collaborate with the Brooklyn Waterfront Research Center that the college has established.

Challenges: The project is running late since it was awarded a semester later than expected. Organizing meetings and events are quite challenging due to varying schedules of faculty members.

MATHEMATICS

326
Pi: Nancy Baxter Hastings
Institution: Mathematical Association of America (MAA)
Project Title: Professional Enhancement Program (PREP)
Project Number: 0817071
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: The goal of PREP is to enable faculty in the mathematical sciences, from all types of institutions and at all stages in their careers, to respond to rapid and significant developments that impact undergraduate mathematics by offering extended professional development experiences.

Methods & Strategies: All PREP workshops feature active involvement by participants, leadership by experts, and a commitment by participants to make use of what they learn. To achieve a sustained impact, each workshop has a preparatory, intensive and follow-up component.

Evaluation Methods & Results: Based on responses on pre- and post-workshop questionnaires, participants overall satisfaction with their experiences is very high. A deeper question of interest is how these (positive) experiences lead to more effective practice once faculty return to the classroom. To help strengthen the follow-up component, a formal reporting process was initiated for the component in 2009. In addition, workshop leaders are asked to identify participants whose follow-up activities are exemplary to present posters at the Joint Mathematics Meetings at the session on NSF-DUE projects.

Dissemination: PREP has offered 123 workshops, 19 of which were held online. The workshops involved a wide variety of mathematical topics, ranging from geometry to mathematics and politics and from curricular issues related to preparing computer scientists to teaching courses in mathematical biology.

Impact: Between 2001 and 2011, over 2,500 faculty learners, from all types of institutions, including two-year colleges, liberal arts colleges, minority-serving institutions, comprehensive universities and research universities, participated in PREP workshops. The workshops provided a sustained professional development experience and were equally open to all faculty, independent of whether or not they are members of the MAA or any other professional organization.

Challenges: The most unexpected challenge for PREP has been the impact of the severe economic downturn on PREP’s goal to move towards making the program sustainable. Our goal was to cover 50% of program costs by 2011, by gradually raising registration fees, increasing the number of participants and finding sufficient partners. Before the downturn, we were moving towards this goal. Then, even though we reduced registration fees for workshops by half and began providing travel support to a limited number of participants, the number of participants declined and some workshops had to be cancelled.

327
Pi: Connie Campbell
Institution: Millsaps College
Project Title: Research Based Videos for Developing Mathematical Thinking Skills in Proof Writing and Problem Solving
Project Number: 1020161
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We are creating videos of students constructing proofs and editing those in such a way as to help students strengthen their abilities at problem solving and proof construction. Our project entails the creation and design of the videos and related materials to enhance student learning related to proofs.

Methods & Strategies: We are creating videos that further address transition issues. Toward this end we are working with faculty from different types of undergraduate institutions and using their feedback to inform us in the types of videos which will be most useful for a wide variety of institutions.

Evaluation Methods & Results: Our evaluation methods include pre and post surveys, post video questionnaires, and pre and post tests. Additionally, we are planning interviews with instructors and selected students.

Dissemination: We have held the first of three 3-day summer meetings with the PIs and faculty from six additional institutions, have created a resource website which contains our videos to date and instructor blogs, and have led a minicourse and other presentations in the use of our current videos.
**Impact:** Each of the three PIs has witnessed improvement in the proof writing skills of their students, particularly at the middle ability level. That is, antitodal information indicates that the discussions held around the videos we have already developed have been helpful to students who are in the middle quartile of our classes.

**Challenges:** The biggest challenge comes from the fact that we don’t create scripts for the video sessions, rather we have an idea we’d like to see students work through and so record them working on problems that we believe will give rise to such a situation. This means that students being taped may or may not take the path we hoped, and consequently we sometimes have several hours of footage without much usable material. Nevertheless, we believe it is important that the students being taped generate their own ideas and so deem the time intensiveness of our process worthwhile.

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**328**  
**PI:** Scott Dexter  
**Institution:** Brooklyn College  
**Project Title:** Linear Algebra In New Environments (LINE)  
**Project Number:** 0837331  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We are developing modules for Linear Algebra through a collaborative effort involving both STEM and mathematics education faculty at four different universities. We are building a professional community while developing the modules and conducting classroom research on their effectiveness.

**Methods & Strategies:** We began with group online calls over the summer and conducted a reading seminar on mathematics education research literature. We hold project meetings 2-4 times a year to build materials and reflect on our work. The modules are implemented, data is gathered, and we are analyzing this data.

**Evaluation Methods & Results:** We are using a combination of classroom video, student interviews, analysis of student work, and student feedback. We are in the process of gathering data and plan to begin analysis this summer.

**Dissemination:** We have made several presentations at national conferences and also published some preliminary results in peer-reviewed journals.

**Impact:** We have managed to build strong ties between the STEM faculty and mathematics education faculty at each of our institutions. We have been working together, presenting, and publish together. We have built a significant cross-college professional community.

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**329**  
**PI:** Ivo Dinov  
**Institution:** UCLA  
**Project Title:** Statistics Online Computational Resource for Education  
**Project Number:** 0716055  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The overarching goal of the Statistics Online Computational Resource (SOCR) is to design, validate and freely disseminate knowledge. Specifically, SOCR provides portable online resources for probability and statistics education, technology based instruction and statistical computing.

**Methods & Strategies:** SOCR employs modern information, technology, networking and pedagogical resources to design, validate, and widely disseminate web-based interactive applets, computational and graphing tools, instructional and course materials to enhance undergraduate training.

**Evaluation Methods & Results:** We use a 2-tier mechanism for evaluation of all SOCR materials experimental designs of pedagogical efficacy (comparison between control and SOCR-treatment groups), and infrastructure utilization metrics (citations, server-utilization, diversity of users, SOCR awards and recognitions, course utilization and volume of trainees).

**Dissemination:** SOCR motto is: It’s online, therefore it Exists! This implies that all SOCR applets, learning materials, publications, tutorials, hands-on activities and instructional resources are always openly accessible online via one of the 6 complementary SOCR servers (http://wiki.stat.ucla.edu/socr/index.php/SOCR_Servers). Each year, we organize workshops, participate in National meetings and train students and instructors on utilizing modern web-technologies for STEM education (http://wiki.stat.ucla.edu/socr/index.php/SOCR_News).

**Impact:** SOCR materials and resources are peer-reviewed and included in dozens of international digital resource libraries (http://www.socr.ucla.edu/htmls/SOCR_Recognitions.html). There are 2 SOCR mirror servers (ASA and PhyResearch.org). SOCR tools and materials are included in 3 EBooks and 7 print-only textbooks (http://wiki.stat.ucla.edu/socr/index.php/SOCR_Books). Since 2005, SOCR resources have been utilized by over 4.5 million (daily-unique) users.
Challenges: There were 2 types of unexpected challenges we encountered resource usability and technology extendibility and interoperability. The resource usability problems are typically reported by outside learners, educators and investigators. These are prioritized and addressed in an ad hoc fashion.

Technological challenges related to the rapid growth of the SOCR resources, and the advent of novel IT tools, often require resource redesign, abstraction and refactoring to ensure SOCR materials and computational libraries are efficiently accessible by machine- and human-interfaces.

Impact: We are still in the very early stages. We believe we will have an impact on both student content learning and student attitude toward mathematics. We believe that engaging, phone-based apps have the potential to change the dynamic of how students study mathematics, primarily because, unlike textbooks, tablets or computers, students carry their phones with them everywhere they go. For this reason we believe that other instructors of this course will be eager to use the material, so we expect broad use of this material by the end of the grant period.

Challenges: We have already encountered issues with the relatively longer development time to get material posted for Apple platforms. We anticipate needing to hire a student programmer in year 2 to help with this, but we have funds set aside for this purpose.

330
Pl: Douglas Ensley
Institution: Shippensburg University
Project Title: Mobile Math Apps
Project Number: 1140299
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goals of this project are the development of self-contained modules for a precalculus course, the creation of new designs and user interfaces suitable for mathematics on a mobile device, and the investigation of smartphone usage habits of students and rudimentary assessment of the impact of mobile technology on student learning.

Methods & Strategies: We will develop our mobile apps using Adobe Flash, and we will compile for both Android devices and iOS (iPhone) devices. For assessment we will be collecting extensive phone usage data, pretest/posttest for content knowledge, and focus group research to evaluate user interface design.

Evaluation Methods & Results: The apps will be developed summer 2012 and first tested Fall 2012, so all results will be preliminary. Our plan is to correlate usage data with content learning using experimental and control groups within a single section of a precalculus course to control for other variables. In subsequent semesters the subject group will be broadened. In addition we will correlate usage data with user interface focus group in order to understand how the students use the phone-based apps.

Dissemination: Our main dissemination will be through conference presentations (Joint Mathematics Meetings and International Conference on Technology in College Mathematics) while data is preliminary, and then journal publication at the end of the project. Once tested, all apps will be publicly available on both Google Play (i.e., Android Market) and the Apple iTunes App Store.

331
Pl: David Feikes
Institution: Purdue University North Central
Project Title: Connecting Mathematics for Elementary Teachers (CMET) Type II: Dissemination, Enhancement and Research
Project Number: 1022942
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: The goals of this project are to develop 60 videos about how elementary children learn mathematics. These videos will be evaluated for their effectiveness with preservice teachers at various universities in mathematics content courses. The findings will be disseminated through conference presentations, papers, and faculty workshops.

Methods & Strategies: The videos are one-on-one interviews with the principal investigators. Notes are taken on each interview. Selected segments from multiple interviews are chosen to illustrate how children think mathematically. For example, one video highlights how second-grade children do subtraction in different ways. Commentary is added at the beginning and end of each video.

Evaluation Methods & Results: Evaluation plan: Once a significant number of videos are completed, they will be incorporated at various universities in mathematics content and mathematics methods courses for elementary teachers. University students will be asked to complete an online survey after viewing each video. Instructors of these courses will be asked to assess the effectiveness of the videos in their courses. In a separate study, some of these videos have been used with parents. Preliminary data indicates that the videos were beneficial to parents in helping them understand how their children were thinking about mathematics and how they might help their children.
**Poster Abstracts**

**Dissemination:** We made presentations on these videos at the National Council of Teachers of Mathematics Annual meeting in April 2011 in Indianapolis, IN and at the Early Childhood Education Conference in Westville, IN in 2012. We have submitted papers/presentations to PME-NA in Kalamazoo, MI; NCTM in Denver, CO; and AMTE in Orlando, FL.

**Impact:** Our goal is to impact the mathematical understanding of students in mathematical content courses for elementary teachers and to improve the specific mathematical knowledge necessary for teaching mathematics. We also hope to help instructors of these courses understand the value and power of focusing on knowledge of how children learn mathematics in both content and methods courses.

**Challenges:** We had a very difficult time editing videos with one of the best, but most complex, video-editing programs, Adobe Premiere Pro. However, after extensive study and consultations with experts we are now able to produce high quality videos. Initially, we had other equipment and filming issues, such as cameras that shut off after 30 minutes, issues with sound quality, and establishing appropriate camera angles of children, which we have since addressed.

**332**

**PI:** Charles Funkhouser  
**Institution:** California State University Fullerton  
**Project Title:** Native American-based Mathematics Materials for Integration Into Undergraduate Courses  
**Project Number:** 1122823  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:**
1. Further developing and enhancing materials (both print and instructional technology-augmented lessons) based in those traditions, mathematics and other intellectual fields at CSUF, Turtle Mountain Community College, and other sites  
2. Fostering faculty expertise in the materials — mathematics, methods and cultural bases through classroom-ready lessons and established, previously utilized instructor-training models,  
3. Assessing the materials — effects on student attitude and dispositions toward mathematics, and  
4. Making these materials available for wider dissemination to other universities, and Tribal and community colleges—especially those serving this underrepresented student population, American Indian undergraduates.

**Methods & Strategies:**
1. Prototype materials developed during Phase 1 are being reviewed, revised, and enhanced by technology-based and other methods; additional lessons also will be developed by the CSUF/TMCC cohort  
2. Revised/enhanced materials are being piloted, revised and reutilized at CSUF and TMCC, then later at other sites  
3. Data will be collected by the Project Evaluator on materials efficacy and effects on student and faculty affect, and student performance.

**Evaluation Methods & Results:**
1. A finalized evaluation framework has been designed and approved.  
2. Pre- and post-survey items have been reviewed by Senior Personnel and course instructors.  
3. Pre- and post-surveys have been approved by the Project Evaluator and PI.  
4. Focus group protocols have been reviewed and refined by relevant Senior Personnel.  
5. The following pre-program data will be collected: survey responses, focus groups, and performance data.  
6. Collection of post-program data: survey, focus groups, and performance data. The Evaluator will be present at identified university, Tribal and community college campuses during periods of data collection.  
7. Data will be reduced and analyzed by the evaluator using standard methods of survey and performance analysis.  
8. A narrative final report will be written and submitted to the PI for wider dissemination (including the technology-related media given above), with results presented at regional and national meetings of university and community college mathematics educators (such as MAA/AMS, NCTM, AMATYC, SSMA, ISTE and RMMC), and submitted for publication in reputable mathematics education journals (such as the Journal of American Indian Education and those of the preceding organizations). This final report also will be submitted to NSF.

**Dissemination:**
1. Monthly on site faculty updates on materials’ progress at CSUF and TMCC  
2. Local, State, regional and national meetings, such as MAA/AMS joint meeting in Boston (poster session and paper) and Tribal Gathering at Scottsdale Community College in AZ to enlist new collaborators  
3. Periodic email updates to Project group distribution list  
4. Future plans): Results and materials from this project will be submitted for publication in refereed journals, including those published by MAA/AMS, NCTM, AMATYC, SSMA, ISTE and RMMC and other professional organizations, and via presentations at professional meetings of these organizations.

**Impact:**
1. Widespread undergraduate participation in courses enumerated in Project Description at CSUF and TMCC campuses with positive affect results on diversity in mathematics education measured by Evaluator’s instrumentation
2. Enthusiastic participation by CSUF/TMCC mathematics faculty with focus group data suggesting affect and mathematics growth in knowledge and importance of Native American-based content

3. Numerous new collaborators on Project from dissemination efforts, especially SCC Tribal Gathering (Pima, Navajo, and Hopi Nations)

4. Additional impacts anticipated during the execution of the Project as given in the Project Description Outcomes and Objectives for NSF DUE 1122823 as given below.

**Challenges:**

1. Challenge of starting a course-dependent Project such as this after the Fall semester had started. We used this truncated time for finding additional points of integration of the materials and Project participants on both campuses and ad hoc startup of materials development and other activities in courses where possible.

2. The amount of time required for 'start up' after the NSF awarding was made to get all personnel 'online' with the SRO at CSUF and partner institution, TMCC-PI and other Senior Personnel devoted additional after hours and weekend time to make this happen.

**333**

**Pi:** Joan Garfield  
**Institution:** University of Minnesota  
**Project Title:** Collaborative Research: The CATALSTS Project, Change Agents for Teaching and Learning Statistics  
**Project Number:** 0814433  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The first goal was to develop a college-level introductory statistics curriculum that develops students' understanding of statistical inference through the exclusive use of randomization and bootstrapping methods. The second goal was to train faculty at diverse institutions to implement the curriculum.

**Methods & Strategies:** Materials were adapted from two past NSF-funded projects, and new materials were developed. PIs from the previous projects collaborated on the curriculum project. Faculty workshops, bi-weekly conference calls, and faculty onsite visits to observe class sessions were used to support implementation.

**Evaluation Methods & Results:** Three assessment instruments were developed to collect evaluation data: A 27-item multiple-choice test called GOALS to measure statistical reasoning, a constructed response test called MOST to measures statistical thinking, and an instrument called AFFECT to measure students' attitudes toward statistics. All instruments were administered to students enrolled in CATALST and non-CATALST statistics courses at each participating institution in fall 2011, and again at the end of spring 2012. Data will be analyzed during summer 2012, and preliminary results will be included in the final project report.

**Dissemination:** We have made five poster presentations and five presentations at national and international conferences, conducted three workshops, and made presentations to seven mathematics and statistics departments at universities and colleges in the United States and Belgium.

**Impact:** We have developed expertise with a group of 20 instructors from 15 different institutions to either implement the entire CATALST curriculum or integrate parts of the curriculum into their introductory statistics courses. About half of the instructors plan to continue to teach the complete CATALST course in subsequent years, while others plan to continue to use parts of the CATALST curriculum they incorporated into their course. We expect that these faculty will inform others who will become implementers the CATALST curriculum in the future.

**Challenges:** The biggest challenge was producing a coherent course that supported the development of students' understanding of statistical inference. Testing out activities in the classroom and classroom observations indicated where changes and additions were needed. The challenges were met through the creativity and diverse talents of the research team who developed new learning activities, tested the new activities in the classroom, and modified activities based on assessment data, student feedback and classroom observations.

**334**

**Pi:** Thomas Judson  
**Institution:** Stephen F. Austin State University  
**Project Title:** Collaborative Research: UTMOST: Undergraduate Teaching in Mathematics with Open Software and Textbooks  
**Project Number:** 1020957  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** The goal of this project is to demonstrate the use of Sage, which is comprehensive free open source mathematics software, coupled with existing free open textbooks, as a tool for faculty and institutions to more easily bring the power of mathematics software to their students.

**Methods & Strategies:** UTMOST converts existing open textbooks into web-based electronic texts that integrate traditional mathematical exposition with Sage code and hands-on demonstrations. Materials will be tested at undergraduate institutions with the goal of improving the teaching and learning of mathematics.

**Evaluation Methods & Results:** Information is being gathered on the processes and outcomes of the project at different stages.
for formative and summative evaluation. Results will be organized as case studies of participating instructors and their students. Formative components will focus on monitoring the quality of project activities, enabling the project to make mid-course corrections and planning for future development. Summative components will focus on the impact of the project on instructors' instruction and student learning at the test sites.

**Dissemination:** We have shared the results of UTMOST through a variety of forums, several of which are already in place. Forums for dissemination include the Sage website, Sage Days workshops, national workshops and presentations, and the American Institute of Mathematics open textbook initiative.

**Impact:** Our anticipated impacts are improving the teaching and learning of mathematics through the integration of open textbooks with open software. Integrating software with textbooks will allow students to explore concepts with more complicated examples. We are currently collecting data from our first test sites.

**Challenges:** We have been fortunate in that we have not encountered major challenges.

**335**

**PI:** Karen Keene  
**Institution:** North Carolina State University  
**Project Title:** CELTIC: Calculus for Elementary Teachers: An Innovative Context  
**Project Number:** 0942843  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** We will develop the first course in a two semester sequence intended for preservice elementary teachers in a STEM-focused elementary education department. The course will use appropriate pedagogy to teach these students the foundations and beginnings of derivative while integrating the big ideas of calculus with the elementary mathematics content the students will need.

**Methods & Strategies:** We are developing the materials using a design research methodology. We create the materials using the research about student learning that is available, then pilot them in small group focus-type interviews, make changes, pilot again, and then use in a classroom. After that, the materials are revised once again.

**Evaluation Methods & Results:** We have piloted the course and collect data about student learning using validated tests such as the LMT and the CCI. Evidence shows that the students did increase their understanding of elementary mathematics content for teaching and calculus, but only slightly. We will be sending out the materials for review this summer.

**Dissemination:** We have made presentations at the Mathematics Association of America and the Research in Undergraduate Mathematics conferences for two years. We have talked with many people about it and published two proceedings papers. We intend to send out papers for publication and present at the Association for Mathematics Teacher Educators next year.

**Impact:** We have been successful in institutionalizing the course and it will be required of all elementary preservice teachers. We have talked with many faculty and they are somewhat hesitant, but very interested in our work and supportive. The three departments that are collaborating (Elementary Education, Mathematics Education, and Mathematics) have forged a strong working relationship which will continue after the project is over.

In the future, we hope to send materials to many other elementary education schools who are interested in strengthening their students STEM backgrounds.

**Challenges:** The amount of time necessary for four people (Three PIs and a graduate student) to develop materials has proved extensive. Also, working with freshman who have to integrate into university academics and greet this new kind of material has been a challenge. We are making changes to the curriculum right now to address this.

**336**

**PI:** Taufiqr Khan  
**Institution:** Clemson University  
**Project Title:** Emphasizing Core Calculus Concepts Using Biomedical Applications to Engage, Mentor and Retain STEM Students  
**Project Number:** 1044265  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of the project is to develop modules to provide freshman and sophomore STEM students applied learning experiences that connect mathematical concepts with bioengineering and medical applications.

The STEM students who are able to apply mathematical concepts to critical health care decisions.

**Methods & Strategies:** Students enroll in one applied learning module per semester for up to four semesters. The proposed modules will emphasize mathematics and statistics relevant to four biomedical research areas: 1) orthopedics, 2) infectious diseases, 3) heat propagation in the human body, 3) mammography and radiology.
**Evaluation Methods & Results:** The assessment of the project will consist of a formative and summative evaluation. Pre and post surveys, follow-up surveys, and exit interviews will be used to assess the student's satisfaction with the modules, usefulness of the field-trips, and gauge student understanding of uses of mathematics in STEM fields.

**Dissemination:** The project team will share all teaching materials, assessment results, and improvements via a project website. In addition, project members will present methods and findings at national conferences to inspire other institutions to adopt similar applied learning experiences.

**Impact:** Insuring that the at risk students do not falter in calculus and abandon their STEM goals. Advanced high-schools and universities around the country have expressed interest in developing similar biomedical applied learning experiences in their institutions.

**Challenges:** Nothing at this point in time.

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**337**  
**PI:** Sandra Kingan  
**Institution:** Brooklyn College  
**Project Title:** Mathematics and Social Advocacy  
**Project Number:** 0942670  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The main goal is the development of new course(s) that will build a community of students and faculty knowledgeable about mathematics and social advocacy, in the sense that they will be able to act as advocates for the societal issues they care about. The dual focus of the course-learning the mathematics rigorously and using it in advocacy, will create in students an awareness of how mathematics applies to society.

**Methods & Strategies:**  
- Development of new courses  
- Preparation of textbook  
- Incorporation of civic engagement component

**Evaluation Methods & Results:**  
- Four curriculum evaluators  
- One project evaluator

**Dissemination:** Website on CUNY's Academic Commons bringing together math faculty with civic engagement interests: http://applicationsofmathematics.commons.gc.cuny.edu/  
Website on PI's homepage advertising course: http://userhome.brooklyn.cuny.edu/skingan/courses/mathmethods/

**Impact:** Students: 2 of 5 students who took the pilot course last Spring graduated and are in graduate school. The remaining 3 are applying to graduate school at present. The REU type term-project played a role in their success.  
Faculty: several faculty at the JMM poster session like the course and are waiting for the textbook to be completed so as to teach a similar course.

**Challenges:**  
1. Figuring out underlying commonality of the techniques;  
2. Rigorous presentation of the mathematics (no hand-waving);  
3. Packaging learning material into concise portions that can be covered in the classroom in two to four weeks; and  
4. Difficult getting the course approved. Too cutting-edge for some faculty. Fortunately the theme of math awareness month this year is 'Mathematics, Statistics, and the data deluge' which is precisely the focus of the course. This helped.

**338**  
**PI:** Eugene Klotz  
**Institution:** Drexel University  
**Project Title:** Math Images II  
**Project Number:** 1022907  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal of this project is to develop a website which gives contributing undergraduates a powerful and transforming educational experience, and is also a valuable teaching and exploratory resource.  
www.mathforum.org/MathImages

**Methods & Strategies:** The Math Images II project involves undergraduate students working to develop wiki pages that introduce and describe the math content of images they find interesting. They write, explaining the mathematics behind the images, and even develop ancillary images.

**Evaluation Methods & Results:** Previous evaluation findings targeted understanding the experience of participating students, assessment of open-ended mathematics writing, and how users read mathematics and work with images on wiki pages. They indicate that participating students perceived themselves as having increased their abilities to write mathematics and their confidence in their abilities to learn mathematics. They also led to more effective methods of providing feedback in order to enhance the mathematical accuracy of their writing, and an independent quality check on the mathematics writing.

**Dissemination:** We will follow normal means of dissemination, and in addition the public Math Image site should become well known because the site and pages as they are developed will appear on the Math Forum, which receives over three million visits a month.
Impact: Our interactive, personalized, community-oriented, highly visual approach appeals to many students, in particular women and minorities. Moreover, it is very successful with students just finishing their freshman and sophomore years, who are normally unable to undertake research activities because of their lack of background. It offers these students an effective STEM experience and it gives faculty a convenient and useful venue for student research.

Challenges: At the last minute one of our partners was forced to pull out. His group was one of two that were to work during the academic year, as opposed to summer workshops. Fortunately, a school teacher was available who had been heavily involved during the summer in helping the undergraduates write clear and interesting mathematics, suitable for school students. He organized special 'honors' projects in two of his school courses, and these were closely supervised by two of the undergraduates, giving breadth and depth of experience to all involved, in what seems to be a new and exciting direction.

339
PI: Sandra Laursen
Institution: University of Colorado Boulder
Project Title: Collaborative Research: Research, Dissemination, and Faculty Development of Inquiry-Based Learning (IBL)
Methods in the Teaching and Learning of Mathematics
Project Number: 0920126
Type: Phase 2/Type 2 - Expansion
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: Four universities with expertise on Inquiry-Based Learning (IBL) in college mathematics are hosting intensive, multi-day workshops on IBL for college math instructors. The workshops seek to provide faculty with the knowledge, skills and collegial support needed to implement IBL approaches in their own classrooms in a variety of mathematical subjects. NOTE: This project is a collaborative project and this application is submitted by one PI out of the five participating institutions, representing the evaluation team.

Methods & Strategies: Four to five day workshops are offered each summer (2010-12; possibly with an extension and extra workshop in 2013). The workshops feature presentations, video case studies, discussion, sharing of sample materials, and the presenters represent a range of institutional types, course types (introductory to advanced) and styles of applying IBL. Participants are drawn into an existing, lively community of IBL practitioners supported by the Academy of Inquiry Based Learning.

Evaluation Methods & Results: The workshops are evaluated through surveys of all participants and interviews with a selected subset. The pre-workshop survey addresses participants' motivation to teach with IBL, prior knowledge and skills in IBL teaching, and their beliefs about IBL and student effectiveness. It also assesses their current use of specific faculty- or student-centered instructional activities. The immediate post-workshop survey collects comparative data on participants' knowledge, skills, beliefs, and motivation and asks about their plans to implement IBL. A follow-up post-survey administered one year after workshop participation gathers comparative data on instructional activities; interviews are used to dig deeper into faculty practices and reasons for adopting (or not) various IBL approaches.

Pre/post workshop results for 2 workshop cohorts show that, during the workshop, faculty make strong gains in IBL knowledge and moderate gains in IBL skills. Their beliefs in IBL's effectiveness and motivation to use it - already strong - become even stronger. Follow-up results for the first cohort suggest that 70% of respondents have made significant moves toward greater use of student-centered teaching in the year following the workshop. Data collection is ongoing.

Dissemination: Workshops have been advertised through the Mathematics Association of American MAA PREP program and the Academy of Inquiry Based Learning. Presentations have been made at the Joint Mathematics Meetings (2 posters, Jan. 2012) and Research on Undergraduate Mathematics Education (RUME) annual meeting (1 talk, Feb. 2012). We hope to extend the evaluation study through a no-cost extension to gather follow-up data on all 3 workshop cohorts, and to prepare a scholarly manuscript.

Impact: As noted above in the evaluation results, we have evidence that the workshops have an impact on faculty participants' knowledge, skills and beliefs. More importantly, we are beginning to see indications that faculty are making substantial changes to their practice that shift their teaching practice in directions more consistent with how students learn. Over 100 faculty have attended the two workshops offered to date, and over 25 presenters have contributed. A third workshop will be offered in summer 2012, and potentially a fourth in 2013. We do not have student data, and are not funded to collect it.

Challenges: An ongoing challenge for the workshop organizers and presenters is to use active learning methods to involve faculty in learning about IBL through methods themselves consistent with IBL - that is, not to lecture about active learning. As the evaluator, I observe that the independence of the workshop sites from one another makes organizing the workshop efficient, but expertise or learning from the workshops that might suggest improved practice is not always passed along to the next organizer. An ongoing challenge for the evaluation is to know how much we can trust participant self-report of teaching practice. We would like to conduct classroom observations to check on the validity of our self-report instrument.
**340**

**PI:** Barbara Margolius  
**Institution:** Cleveland State University  
**Project Title:** Flash Applets for WeBWorK Online Homework System  
**Project Number:** 0941388  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Build a collection of Flash enhanced online homework problems for calculus, pre-calculus and differential equations. Make the problems available through the National Problem Library. Make the problems extensible by others. Publicize the availability of these resources through the MAA's WeBWorK wiki, and the National Science Digital Library.

**Methods & Strategies:** We are developing applets written in Flash that run within WeBWorK online homework problems. The WeBWorK homework system has been supported by a series of NSF grants and is now also supported by the Mathematical Association of America.

**Evaluation Methods & Results:** We are using the Calculus Concepts Inventory to assess student learning and expert assessment to assess the appropriateness and effectiveness of our homework problems.

**Dissemination:** We are disseminating our work through the WeBWorK National Problem Library, national meetings of the Mathematical Association of America and the American Mathematical Society, the WeBWorK MAA wiki and the National Science Digital Library.

**Impact:** The project has broadened the variety of homework problems possible. It facilitates teaching and assessing conceptual understanding of mathematical topics. It allows a variety of input methods for homework.

For example, we can assess whether a student has a graphical understanding of the concepts of derivative and antiderivative by having them sketch these graphs, grading their work by computer, showing them their errors and giving them additional tries.

**Challenges:** We have had to work on the interface between the WeBWorK system and the applets. We have addressed this issue by adding another co-PI to the project and becoming more actively involved in the development of the open source WeBWorK project.

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**341**

**PI:** Maura Mast  
**Institution:** University of Massachusetts Boston  
**Project Title:** Common Sense: Quantitative Reasoning in the Undergraduate Curriculum  
**Project Number:** 0942186  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Develop and test course materials that use current technology to teach quantitative reasoning in context. Document how the use of this material helps students improve problem solving and quantitative reasoning abilities. Develop an online problem submission platform for QR faculty to use.

**Methods & Strategies:** Development and implementation of a textbook that emphasizes using common sense to tackle numeracy questions encountered in daily life. We have taught from and subsequently revised the text during the project; we have also developed an online teaching blog and support materials.

**Evaluation Methods & Results:** We ask all students to take pre- and post-course attitudinal surveys each semester, including sections of the course that did use the project materials and sections that did not. We also holistically grade common final exam problems using student learning outcomes for the course, again for sections using the project materials and sections not using them. We plan to conduct student focus groups to determine longer-lasting effects (in terms of problem-solving ability and attitudinal change) of the material; we will also interview faculty. This evaluation is in process and we have no summary information yet.

**Dissemination:** The project materials are freely available on the web; as a result, faculty at other institutions have begun using the project material. We sponsored a regional quantitative reasoning conference in March 2011, and presented our philosophy and material. The PI also presented at a national math meeting.

**Impact:** Initial impacts: At our institution, student and faculty have been positively impacted by the project activities. All quantitative reasoning faculty now teach with the new material and this move has prompted wide-ranging discussions about pedagogy and student learning outcomes; initial reactions have been very positive. Students praise the meaningful connections between course material and approaches (use of computer as a tool in problem solving, for example) and real life. We also anticipate a broader impact as we disseminate our material to a wider audience.

**Challenges:** Data collection and evaluation have been more difficult than anticipated. In response to the data collection issues, we put in place more consistent oversight for the pre- and post-survey process. It has been challenging to determine a proper approach to evaluation of the data and we have had technical issues related to our survey software that have only recently been debugged.
342
PI: Douglas Meade
Institution: University of South Carolina
Project Title: Collaborative Research: Maplets for Calculus (M4C)
Project Number: 1123170
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Creation of a comprehensive collection of applets, the Maplets for Calculus (M4C), addressing the conceptual and manipulative aspects of Calculus (and Precalculus). Designed for use by both students ('tutor without the tutor') and instructors (in-class demonstrations). To analyze the efficacy of using the applets to teach Calculus (and Precalculus). To make the applets available on mobile devices.

Methods & Strategies: Most homework systems only check final answers. The M4C applets (i) guide the students through the solution process and check intermediate results, (ii) have more variation than problems in online homework systems, and (iii) reinforce graphical, numerical, algebraic and verbal approaches when possible.

Evaluation Methods & Results: Students complete pre- and post-course surveys on their attitudes about technology and the M4C and rate each applet. Faculty complete post-course surveys on their attitudes about the M4C and rate each applet. The results will help students and faculty decide which applets to use and will help the researchers improve the applets. The attitudinal surveys help the PIs determine the usefulness of individual applets in the teaching of specific topics. Project personnel are devising a protocol to evaluate student interaction with the applets. A goal is to identify pedagogical features that have the biggest benefit for students.

Dissemination: The M4C are used at 6 universities and by 2000 students in 42 countries on 6 continents. The M4C are free at Texas A&M and at the U of South Carolina but are sold to others at MYMathApps.com. About 10% of the M4C are available free through MYMathApps.com and the MathDL. We have 2 conference papers, and have plans to prepare at least one paper for submission in Loci. The M4C are being incorporated into an online textbook.

Impact: Pre-course student attitudes vary between the test sites. In general, the M4C were most appreciated by students who were most apprehensive about calculus, noting the instantaneous feedback and endless patience of the M4C system. The post-course surveys indicated that students find the M4C more beneficial than Maple or MATLAB. Instructors report that some applets help students build their intuition, and some are useful as lecture demonstrations. The ideas and methodologies are transferable to other STEM disciplines. Each applet has been implemented to facilitate translation into other languages.

Challenges: We would like better support from our faculty colleagues to encourage more students to make use of the M4C. We would like to incorporate a grading system into the M4C. However, serious security issues arise from doing all the computation and grading on the student's machine. By porting to mobile devices and doing the computation and grading on the server, we will be able to resolve these security issues. The current M4C are displayed in Java but Java will not work on mobile devices. So we are porting the applets over to HTML5 and JavaScript.

343
PI: Mary Nelson
Institution: University of Colorado, Boulder
Project Title: Colorado Momentum: Oral Assessment in the Mathematical Sciences Classroom
Project Number: 0817417
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Our project was designed to improve the understanding and grades of mathematics students. We wanted to increase the number of and retention of STEM majors and retain them at the university in STEM majors. We wanted to increase student confidence and satisfaction with their courses.

Methods & Strategies: We offered students one hour, ungraded, optional oral reviews before each written unit exam. Five to six students met with a facilitator to discuss the important concepts to be covered on the exam. They were able to construct their own knowledge, negotiate meaning and make mathematical connections.

Evaluation Methods & Results: We have used both qualitative and quantitative methods to analyze our data. We found that orals participants averaged .7-1 letter higher grades than non-participants. We administer a placement test that predicts about 50% of the variance in students' course grades. This helped us determine that students of all ability groups benefit from oral reviews. Surveys showed increased confidence and a greater understanding of the nature of mathematics. We followed students for two years to determine if the effects of the treatment persisted.

Dissemination: We published a paper in PRIMUS and have another paper in progress. We presented papers at JMM, NCTM, AERA, ISSOTL, ASEE etc. We visited four universities to train faculty and have begun pilot studies in each of those universities. Orals will be offered in two science classes in the fall.

Impact: Data shows that orals participants achieved significantly higher grades and retained at higher rates both at the university and in STEM majors. Students report greater
confidence in their math ability and demonstrate improved understanding of the nature of mathematics. Faculty and teaching assistants have been observed to be more interactive in the classroom and in office hours. They have reported better understanding of student thinking and of misunderstandings and misconceptions held by students. High school algebra students retained at a significantly higher rate than the two control groups.

**Challenges:** Obtaining appropriate rooms for orals has been difficult, but the College of Engineering has provided a room for all orals, as has the Multicultural Engineering program. With these rooms we now have adequate places to facilitate orals. Our other major challenge has been a web-based sign-up system for both facilitators and students. We have gone through several iterations, once starting over from scratch. The current system has proven quite stable and we hope to be able to export it to our partner universities in the summer of 2012.

**Goals & Intended Outcomes:** The field of statistics is changing in response to the increase availability of complex data. To succeed in the workforce our STEM undergraduates need to be facile with computational tasks involving the use of data to address important scientific and social problems. The project aimed to develop a curriculum for training students in the concepts of computing with data, develop education materials to teach these concepts, and hold workshops for developing faculty expertise in this area.

**Methods & Strategies:** Workshops for faculty development were held over four summers. Curricular material was developed and shared with attendees of the workshop. Some of the attendees have subsequently contributed materials in the form of computationally oriented case studies in data analysis and simulation studies.

**Dissemination:** The dissemination activities include: publication of articles on the approach developed; one manuscript is in the process of publication and two others (including a contributed volume of case studies) are in preparation; workshop materials in the form of lecture notes and slides are available for use by educators.

**Impact:** The project has led to the development of successful courses at our universities. These courses are also highly popular with enrollments at our institutions growing 5-fold (e.g. from 50 to over 250 a year at UC Berkeley and from 25 to over 100 at UC Davis) with students from a broad array of fields including undergraduate and graduate enrolling in the course. Although not directly measurable, it is believed that this course has led in part to the dramatic increase in statistics majors. Faculty, especially junior faculty, have found the subject enjoyable to teach.

**Challenges:** With rapidly evolving technology, it is challenging to maintain an up-to-date curriculum. Many key concepts remain constant, but the environment in which they are applied need to be continually refreshed.

344
**PI:** Deborah Nolan  
**Institution:** UC Berkeley  
**Project Title:** Preparing the STEM Work-force for a Data-rich World  
**Project Number:** 0618865  
**Type:** Educational Material Development Proof-of-Concept (EMD-POC)  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** With rich case studies available that capture not just the results but also the activities and thought process of a real-world data analysis, we can greatly enrich the statistics curriculum thus enabling students to see how a statistician approaches an important scientific problem and facilitating instructors in teaching.

**Methods & Strategies:** The approach we take will provide a technological framework for researchers and instructors to create rich, multi-dimensional documents that contain the entire thought process and activities for a real-world data analysis. We envisage an XML-based system for structured documents that acts much like an electronic laboratory notebook. The notebook captures the researchers' computations, analyses, comments, thoughts, notes, and the thought process itself via annotations so that their findings can be reproduced for both themselves and others. In essence, the notebook is a database of all the activities within the data analysis, including the analysts thoughts, code, and written descriptions, and with the capability of rendering different paths through the document in an interactive display.

345
**PI:** Deborah Nolan  
**Institution:** UC Davis  
**Project Title:** Learning From the Scientist’s Lab Book: Designing Interactive Dynamic Documents for Teaching Statistical Thinking and Practice  
**Project Number:** 1043634  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The field of statistics is changing in response to the increase availability of complex data. To succeed in the workforce our STEM undergraduates need to be facile with computational tasks involving the use of data to address important scientific and social problems. The project aimed to develop a curriculum for training students in the concepts of computing with data, develop education materials to teach these concepts, and hold workshops for developing faculty expertise in this area.

**Methods & Strategies:** Workshops for faculty development were held over four summers. Curricular material was developed and shared with attendees of the workshop. Some of the attendees have subsequently contributed materials in the form of computationally oriented case studies in data analysis and simulation studies.

**Evaluation Methods & Results:** Evaluations were in the form of end-of-workshop evaluations. These were used to adapt future workshops and inform the development of educational materials.

**Dissemination:** The dissemination activities include: publication of articles on the approach developed; one manuscript is in the process of publication and two others (including a contributed volume of case studies) are in
Poster Abstracts

**Dissemination:** Plans are to disseminate the infrastructure through the open-source package-system in the R user community. Additionally, a library of case studies will be made available via R packages and will be open for contributions by others.

**Impact:** We anticipate teachers of statistics at all levels (high school, undergraduate, and graduate) will use the case studies developed, and we anticipate a subset of them will in turn contribute case studies to the repository.

**Challenges:** The biggest challenge faced to date are related to the technological challenges of embedding R (statistical software) in the browser.

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**PI:** Dennis Pearl  
**Institution:** The Ohio State University  
**Project Title:** CAUSEmos: CAUSE Making Outreach Sustainable for Statistics Educators  
**Project Number:** 0618790  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** The CAUSEmos program was designed to connect instructors to the statistics education community through the United States Conference on Teaching Statistics (USCOTS), to form collaborations through special interest clusters that move them to the next level in their teaching, to provide mechanisms for them to contribute back to the community of statistics educators as they themselves advance, and to make these efforts sustainable.

**Methods & Strategies:**
1. Mentored faculty focus groups in multiple areas of statistics education;  
2. biennial face-to-face active conferences for approximately 400 participants;  
3. two webinar series monthly (one on teaching & learning and one on specific class activities); and  
4. major virtual conferences (~ 300 participants)

**Evaluation Methods & Results:** The evaluation plan was designed to 1) determine the impact of the program on participants; 2) assess the effectiveness of project interventions; 3) gather information about project activities to help improve programming; and 4) document project activities and participation levels and implementation strategies.

Data collection included participant surveys, follow-up interviews, longitudinal questionnaires, numerical measures of participation; and continual reviews of program processes. Exit surveys found highly satisfied participants for each CAUSEmos activity, follow-up interviews and longitudinal surveys indicated a high percentage of statistics instructors who had participated in CAUSEmos programs had changed their teaching as a result - and the most engaged group (faculty cluster members) were naturally affected the most.

**Dissemination:** The U.S. Conference On Teaching Statistics (USCOTS) held in 2007, 2009, and 2011 averaged more than 420 participants and the upcoming 2013 USCOTS is funded through commercial sponsors and a small registration fee (upcoming virtual conference is similarly funded). USCOTS also hosts 4 associated workshops disseminating results of other CCLI/TUES projects in Statistics. The webinar series have attracted approximately 7000 participants (about 2500 unique individuals).

**Impact:** There are approximately 20,000 instructors of College level statistics nationwide and the CAUSEmos project has connected a full 15% of them to the Statistics Education community marking a dramatic national impact. Multiple new major changes in the way statistics is taught were first presented publicly at CAUSEmos events (e.g. randomization-based methods for teaching statistical inference). Faculty cluster groups in statistics education research, in the study of fun, in the study of on-line teaching of statistics, and in the study of student attitudes and motivations, have more than doubled the number of statistics education researchers nationwide and made valuable contributions to the literature.

**Challenges:** We had more difficulty than expected in bringing programs to those who teach statistics in Social Science Departments (as opposed to our main groups of statistics instructors in Math or Statistics departments). To deal with this problem, we are now partnering with the Interuniversity Consortium for Political and Social Research to reach this audience and have already sponsored two workshops and have submitted new grant proposals with that group.

347

**PI:** Kyle Siegrist  
**Institution:** University of Alabama in Huntsville  
**Project Title:** The Probability Distributome Project: Interactive Teaching of Probability Distributions Theory and Applications using Data, Models and Webapps  
**Project Number:** 1022560  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The Probability Distributome Project aims to introduce, validate and openly disseminate knowledge in the STEM sciences. The Distributome resources include portable online tools for probability and statistics education, technology based instruction and scientific computing.
**Methods & Strategies:** The Distributome infrastructure utilizes modern information, technology, networking and pedagogical resources to create, validate, and broadly distribute web-based learning materials, interactive applets, computational and graphing tools, instructional and course materials to enhance undergraduate studies of probability and its applications.

**Evaluation Methods & Results:** All Distributome web resources are pedagogically evaluated for their factual accuracy, learning usability, interoperability with external hardware and software, as well as their ability to facilitate and enhance the learning experiences. Field testing in classrooms at five universities using validated instruments is planned. In addition, the Distributome project uses a rigorous mechanism for open, community-based review and improvement of the underlying database and computational libraries.

**Dissemination:** The entire Distributome project is open-source and open-utilization. All Distributome learning materials, and resources are openly accessible via the main Distributome server (www.Distributome.org). We organize virtual and face-to-face workshops and presentations; participate in National meetings and train students (http://www.distributome.org/meetings/).

**Impact:** The Distributome resources are developed by faculty, researchers and scientists, including supervised students, to address their specific needs of improving student motivation, enhancing learning experiences and providing lasting understanding of probability theory and applications. We are currently in the process of evaluating the efficacy of the Distributome resources in classroom settings at several US universities.

**Challenges:** There were two types of challenges we encountered. The first one was resource-development related to the need for rapid, agile and efficient webapp design and development. The second challenge was tied to the need to introduce integrated learning materials, computational libraries and user-friendly web-navigation of all Distributome resources. We consulted graphics and web-development experts and cognitive scientists to solicit ideas about the most efficient and intuitive traversal and utilization of the Distributome webapps and learning materials.

**Goals & Intended Outcomes:** Develop, implement, and evaluate interactive Web-based games and corresponding investigative laboratory modules (labs) to effectively teach statistical thinking and the process of scientific inquiry to undergraduate students.

**Methods & Strategies:** We are creating on-line games, developing instructional materials, and evaluating these new materials in classrooms in terms of how well they teach students the investigative process of scientific research, the importance of using statistical thinking and creatively find solutions.

**Evaluation Methods & Results:** The first on-line game (Tangrams) and associated lab was tested in classes by three different instructors. Surveys of the instructors and students as well as results on tests were used to evaluate effectiveness of the game and lab.

**Dissemination:** We are creating a web site where the games will be available as well as the lab materials, references, data collected from the game and ideas for instructors to use in the classroom.

**Impact:** At two colleges so far we have 7 faculty members participating in both creating lab materials for statistics classes and beginning to use them in class. We have interest from faculty from several other institutions in using the games and labs once they are available as web resources, and have already presented at the Joint Mathematics Meetings with a session accepted at the Joint Statistical Meetings to continue to disseminate. The faculty and students participating are already engaged and excited about the possibilities of the labs to enhance statistics education.

**Challenges:** Working on the ability to ensure statistical thinking is an actual part of playing the games rather than just a data collection tool. In one game, attempting to add ability of player to interact with the game as well as sampling issues to address this issue.

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**349**

**PI:** Jeff Suzuki  
**Institution:** Brooklyn College  
**Project Title:** Mathematics and Social Advocacy  
**Project Number:** 0942670  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** To expose students of mathematics to ways that quantitative methods are used in policy formulation. We hope to build a library of curricular materials that can be incorporated across the undergraduate mathematics curriculum.
**Posters Abstracts**

**Methods & Strategies:** We are developing curriculum modules that can be included in undergraduate mathematics courses; we are also developing courses that focus on how mathematics is used to address societal problems.

**Evaluation Methods & Results:** We will be assessing student reaction to the curricular material both in terms of how the real world context improves their understanding of the mathematics, and how their understanding of the mathematics informs their appreciation of real world problems.

**Dissemination:** Talks presented at several math conferences, student math clubs, faculty seminars; several expository papers written on related topics (one accepted, two under review); work with students on research projects. Future activities include workshops and additional talks at mathematics conferences and (proposed) special session.

**Impact:** Anticipated impact includes outreach to students in traditionally non-mathematical majors (e.g., political science, sociology), with a goal of increasing the mathematical awareness of these students. Ultimately we hope to build a multidisciplinary program that will bring together departments of mathematics, social science, and others; to make all students more aware of how quantitative methods can help address social inequities; and to expand the reach of mathematics into the social and 'philosophical' sciences.

**Challenges:** Original plan included outreach to business/industry/government to identify what mathematical tools they felt necessary; severe lack of response meant that inferences had to be made based on academic publications and exhaustive search through legal documents. 'Chicken and egg' problem also arose (needing to have sufficient enrollment to offer class); resolved by breaking materials into smaller components so they could be included in existing courses.

**350**
**PI:** Nathan Tintle  
**Institution:** Dordt College  
**Project Title:** Developing an Innovative Randomization-based Introductory Statistics Curriculum  
**Project Number:** 1140629  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The proposed project will provide a set of curriculum materials with which to teach a substantially different introductory statistics curriculum centered on randomization methods. These materials have the potential for substantially impacting introductory statistics courses across the country.

**Methods & Strategies:** Our project is a collaborative effort between seven instructors involving development and class testing of expository materials, in-class investigations, and accompanying technological tools based on existing and ongoing classroom-based research.

**Evaluation Methods & Results:** Formative assessment results from class testing suggest (a) that the basic premise of our curricular revisions works and (b) numerous potential revisions to the materials. Additionally, based on a full-semester implementation of our materials, we are seeing increases in students’ conceptual understanding of introductory statistics concepts related to the logic and scope of inference (key emphases in our curriculum), both at the end of the semester and four months post-course, with no significant declines in other areas.

**Dissemination:** The PIs have presented at 6 national conferences, published two research articles related to assessment findings and have recently signed a contract with a major book publisher for widespread dissemination of the materials as a textbook. We are planning numerous additional presentations and articles.

**Impact:** The materials have been class tested with approximately 600 students taught by 7 instructors (3 of whom are not PIs on the proposal) at three separate institutions. We are happy with the number of students impacted by the materials to date, with preliminary assessment results showing increased student learning and retention. The ability of non-PI faculty at diverse institutions to quickly and easily adapt to the materials is promising. We anticipate additional impact as we continue to increase the number of class testers and train and work with new faculty who will teach with the materials.

**Challenges:** We have had few, if any, unexpected challenges to date. Modest challenges have involved changing technology needs and arriving at consensus with a large group of authors.

**351**
**PI:** Philip Yasskin  
**Institution:** Texas A&M University  
**Project Title:** Collaborative Research: Maplets for Calculus (M4C)  
**Project Number:** 1123255  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** To create a comprehensive collection of applets, called the Maplets for Calculus (M4C), addressing the conceptual and manipulative aspects of Calculus (and Precalculus) for use as a ‘tutor without the tutor’ by individual students or as in-class demonstrations by instructors. To analyze the efficacy of using the applets to teach Calculus (and Precalculus). To make the applets available on mobile devices.
**Methods & Strategies:** Most homework systems only check final answers. The M4C applets (i) guide the students through the solution process and check intermediate results, (ii) have more variation than problems in online homework systems, and (iii) reinforce graphical, numerical, algebraic and verbal approaches when possible.

**Evaluation Methods & Results:** Students complete pre- and post-course surveys on their attitudes about technology and the M4C and rate each applet. Faculty complete post-course surveys on their attitudes about the M4C and rate each applet. The results will help students and faculty decide which applets to use and will help the researchers improve the applets. The attitudinal surveys help the PIs determine the usefulness of individual applets in the teaching of specific topics. Project personnel are devising a protocol to evaluate student interaction with the applets. A goal is to identify pedagogical features that have the biggest benefit for students.

**Dissemination:** The M4C are used at 6 universities and by 2000 individual students in 42 countries on 6 continents. The M4C are free at Texas A&M Univ. and at the Univ. of South Carolina but are sold to others at MYMathApps.com. About 10% of the M4C are available free through MYMathApps.com and the MathDL. We have 2 conference papers, and have plans to prepare at least one paper for submission in Loci. The M4C are being incorporated into an online textbook.

**Impact:** Pre-course student attitudes vary between the test sites. In general, the M4C were most appreciated by students who were most apprehensive about calculus. They like the instantaneous feedback and endless patience of the M4C system. The post-course surveys indicated that students find the M4C more beneficial Maple or MATLAB. Instructors report that some applets help students build their intuition, and some are useful as lecture demonstrations. Each applet has been implemented to facilitate translation into other languages. The ideas and methodologies are transferable to other STEM disciplines.

**Challenges:** We would like better support from our faculty colleagues to encourage more students to make use of the M4C. We would like to incorporate a grading system into the M4C. However, serious security issues arise from doing all the computation and grading on the student’s machine. By porting to mobile devices and doing the computation and grading on the server, we will be able to resolve these security issues. The current M4C are displayed in Java but Java will not work on mobile devices. So we are porting the applets over to HTML5 and JavaScript.

**Physics or Astronomy**

**352**

**PI:** Andrew Boudreaux

**Institution:** Western Washington University

**Project Title:** Developing Proportional Reasoning in a Physics Context with Invention Tasks

**Project Number:** 1045227

**Type:** Phase 1/Type 1 - Exploratory

**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:**
1. Investigate student facility with ratio reasoning in the context of introductory physics.
2. Develop and test invention tasks as a means to improve facility.
3. Develop a preliminary version of an assessment instrument to measure the strength of students' proportional reasoning skills.

**Methods & Strategies:** Administer written proportional reasoning tasks in introductory physics courses. Conduct talk aloud problem solving interviews with individual students. Analyze responses to document specific reasoning patterns. Develop and test sequences of invention tasks to promote reasoning facility.

**Evaluation Methods & Results:** Compare responses on written tasks before and after invention instruction to assess effects on learning. Compare post-invention performance to performance after traditional instruction for differential efficacy. Compare responses of different populations to assess differences in reasoning facility.

**Dissemination:** Have conducted workshops at: Rutgers University, 2011 NSTA Regional Meeting (Seattle), 2012 PhysTEC (Physics Teachers Education Coalition) National Meeting. Workshop scheduled for AAPT Winter Meeting 2013. We also have a web page under development for disseminating our written materials.

**Impact:** Invention tasks will provide an easy to adapt, supplemental activities that can improve student reasoning about ratio and proportion. Preliminary results indicate that this method helps close achievement gaps for groups underrepresented in STEM. The collection of assessment questions provide a foundation for forming a multiple-choice assessment for proportional reasoning in introductory physics that is valid, reliable, and easy to administer, which will fill a gap that currently exists.

**Challenges:** We received funding later than anticipated and modified our timeline and meeting schedule as a result.
353
PI: Suzanne Brahnia
Institution: Rutgers University
Project Title: Developing Proportional Reasoning in a Physics Context with Invention Tasks
Project Number: 1045250
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes:
1. Conduct research into student thinking about proportion and ratio, and
2. Develop and test an instructional intervention intended to strengthen student proportional reasoning in physics contexts.
3. Develop a prototype for an assessment instrument that will measure the strength of students' proportional reasoning skills.

Methods & Strategies: We are developing sequences of invention tasks designed to promote mathematical reasoning skills that are often expected but lacking in introductory physics students. We are developing test items that allow us to measure, pre and post, students' proportional reasoning both in physics contexts and it everyday contexts.

Evaluation Methods & Results: We have developed assessment items, and are in the process of validating them, to test students' reasoning and sense making in the context of the physics they are learning. These questions also serve as a basis for a comparison we are conducting between students who have had instruction using invention instruction and students who have had instruction using a tradition lecture-recitation format. Some of these questions have been adapted from existing tasks reported in the PER and Math Education research literature, and some have been developed from scratch.

Dissemination: We have conducted workshops at Rutgers University in New Brunswick, NJ, NSTA Regional Meeting in Seattle, WA, PhysTEC (Physics Teachers Education Coalition) National Meeting in Ontario CA, and we are scheduled to conduct a workshop at the AAPT Winter Meeting in New Orleans, LA next January. We also have a web page under development for disseminating our written materials.

Impact: The invention tasks will provide an easy to adapt, supplemental activity that can improve students' reasoning about ratio and proportion. Preliminary results indicate that this method helps close achievement gaps for groups underrepresented in STEM. The collection of assessment questions provide a foundation for the future goal of forming a multiple-choice assessment for proportional reasoning in introductory physics that is valid, reliable, and easy to administer, which will fill a gap that currently exists.

Challenges: We received funding much later than anticipated and modified our timeline and meeting schedule as a result.

354
PI: Kenneth Brecher
Institution: Boston University
Project Title: Light Inquiry Through Experiments: Project LITE
Project Number: 0715975
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Project LITE is developing hands-on and eyes-on experiments, web-based software, curriculum materials and assessment tools about geometrical, physical and quantum optics for use in undergraduate astronomy and physics courses.

Methods & Strategies: We are devising 'homelabs' - hands-on, inquiry-based laboratory experiences that can be done by students at home. Some use the computer as an experimental laboratory - a controllable light source for physics experiments. Others homelabs make use of inkjet printers as experimental apparatus.

Evaluation Methods & Results: We have developed a 'Light and Spectroscopy Concept Inventory' (LSCI). It was trial tested with about 2500 students at 25 colleges and universities. It can be used to assess pre- and post instruction student understanding of its concept domain (mainly quantum). It has been used in courses employing various educational strategies. The LSCI has revealed significant learning gains when students use the Project LITE materials. The detailed analysis of our results was published in the 'Astronomy Education Review' (AER). We are now in the midst of developing a Physical Optics Concept Inventory (POCI).

Dissemination: The Project LITE materials have been presented in AAS, AAAS, ASP, APS and OSA meetings and workshops and in teacher workshops at the Exploratorium, Boston University and elsewhere. Publications include abstracts for all of the professional meetings as well as peer-reviewed papers in the AER.

Impact: The Project LITE web site (http://lite.bu.edu) has received as many as a million hits per year. The 'Spectrum Explorer' Java application is widely used in undergraduate astronomy courses. The more than 250 visual perception applets and activities are used by many psychology instructors and students (both in the U.S. and abroad). The LSCI is being used to assess learning gains in introductory college and university astronomy courses. Several hundred teachers have attended workshops to learn about Project LITE.

Challenges: We are developing novel hands-on experimental activities. A key strategy is to make maximum use of the computer as a piece of experimental apparatus. Controlling all of the screen variables with Flash and JAVA has provided many programming challenges. We are now developing entirely new "inkjet science" activities, which make use of objects that can be
made with an inexpensive printer. We have also developed apps for the iPhone that are freely available for that device. To make them more broadly available, we are now developing apps for all portable devices using HTML5 which presents its own challenges.

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**355**

**PI:** Kelvin Chu  
**Institution:** University of Vermont  
**Project Title:** Vermont Physics Initiative - Improving Quantum Mechanics Undergraduate Education  
**Project Number:** 0942562  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:** To provide longitudinal assessment of modern physics and quantum mechanics understanding in college and graduate students, using validated assessment instruments to measure knowledge and the evolution of ontological beliefs about modern physics and quantum mechanical concepts.

**Methods & Strategies:** We are using the Quantum Mechanics Visualization Instrument (QMVI), Quantum mechanics conceptual Survey (QMCS), Survey of Quantum Mechanics (SQM1 and SQM2). In addition, surveys of ontological quantum mechanics and modern physics beliefs are being deployed.

**Evaluation Methods & Results:** Formative evaluation is conducted each year in analysis of survey results and performance/gains on QMVI, QMCS, SQM1 and SQM2. We have just completed our first year of data collection. Results indicate that students adapt rapidly to the Stern-Gerlach-driven approach of PIPQM (and other texts) and simplifying the mathematics that sometimes proves a barrier in the beginning of the class. Students perform as well on exams as students who have been through traditional texts.

**Dissemination:** We will hold workshops for Vermont physics instructors this summer and next for dissemination. Curricular materials and methodologies we have adopted will be prepared and instruction given to faculty at the three Vermont colleges that offer bachelors degrees in Physics.

**Impact:** The impact is to adopt and disseminate PER-derived instructional strategies to reflect proven pedagogical techniques. Our aim is to fundamentally change the way that quantum mechanics is taught at the University of Vermont (UVM) by adapting materials developed by the Paradigms in Physics group at Oregon State University for the UVM curriculum. These Physics Education Research (PER)-derived materials will be introduced to a 2nd year modern physics course and have been introduced to a 3rd/4th year quantum mechanics course.

**Challenges:** We are actively pursuing methods to change the way that faculty teach physics by providing them with data about the effectiveness of research-based instructional methodologies. To this end, quantitative data, student surveys, anecdotal evidence and incorporation of instructional methodologies into research-based experiences provide a means of increasing faculty buy-in to the process.

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**356**

**PI:** Melissa Dancy  
**Institution:** University of Colorado  
**Project Title:** Collaborative Research: From Dissemination to Adoption: A Study of the Instructional Change Process in Faculty Most Likely to Succeed  
**Project Number:** 1065714  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Developing Faculty Expertise

**Goals & Intended Outcomes:** The large scale goal is to inform a more effective model for sustained STEM reform by studying new faculty undergoing the change process.

**Methods & Strategies:** We are primarily utilizing interview data (pre and post semester interviews of faculty over multiple semesters). Other data collected includes periodic surveys and teaching related artifacts.

**Evaluation Methods & Results:** The main focus of our ongoing analysis is to understand which research-based pedagogies are commonly implemented and how they are implemented and modified as well as the underlying decision making process of faculty, including common barriers and affordances. Initial results indicate that reform is often more difficult than presented by the education research community and faculty need more ongoing support to overcome barriers (many of which are environmental). Additionally, more guidance is needed to help faculty appropriately implement reforms to their unique environment.

**Dissemination:** Talks and posters have been presented at AAPT with more planned this summer. Additionally, we expect to complete a paper on the first year of the project for submission this summer.

**Impact:** We expect the main impact to be on those who are most interested in reform, i.e. curriculum developers and disseminators and policy organizations such as the NSF. We expect our results will explain why the uptake of reform has been slow and offer more impactful ways to bring about educational transformation.

**Challenges:** None
Poster Abstracts

357
PI: Dedra Demaree
Institution: Oregon State University
Project Title: A Multi-institutional and Department-wide Approach to 2nd Generation Introductory Physics Curriculum Reform
Project Number: 0942983
Type: Phase 1/Type 1 - Exploratory
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: Grow a community of practice to develop, share, and document pedagogical content knowledge among graduate students, instructional staff, and faculty members, including members from a 4-year research institution and two community colleges for professional development and improved curriculums.

Methods & Strategies: We take qualitative and quantitative assessments of learning in the physics courses, conduct interviews, teaching observations, and surveys of faculty, an external evaluator assesses the discourse shifts as our community of practice grows, and looks at the effectiveness of our shared documentation process.

Evaluation Methods & Results: Our evaluation takes part on three levels. We evaluate student learning using standardized assessment tests and surveys. This is primarily to establish that the curricular materials we document are leading to levels of success consistent with research-based reformed courses. We also work individually observing classes and interviewing each faculty member to learn their practices and help them articulate their goals for documentation. The external evaluator looks at the growing online database we are developing and joins our community meetings to evaluate discourse, participation, and content.

Dissemination: Our dissemination thus far is aiding additional instructors and faculty members to join the community and understand the goals and best implementation of our documented activities. Equally importantly we are disseminating what we are learning about sustainable professional development and course sharing.

Impact: Our project has a tremendous impact on the members involved in the community - we all feel that we learn from each other, our own goals become more clear and better implemented, and that translates to improved success for our students. The research-based course reforms are also trickling down to new community members and they are feeling less daunted about trying new activities and even drastically new teaching methods. We see evidence that this community building method will make sustainable long-term improvements to courses across all the institutions involved.

Challenges: Faculty do not have time to document their own activities in a way that really encompasses their goals and pedagogical content knowledge. The postdoc who observes the faculty members is busy with documenting observations and conducting interviews and also does not have time for this. Our biggest success in documentation has been during our workshops which means that only a small subset of activities are online thus far. One faculty member was given documentation time in lieu of a teaching load via departmental support, showing the value the department has for the potential impact of this project.

358
PI: Tevian Dray
Institution: Oregon State University
Project Title: Paradigms in Physics: Interactive Electromagnetic Curricular Materials
Project Number: 1023120
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To increase the usability of materials previously developed by the Bridge and Paradigms projects by: 1. improving the effectiveness of the classroom materials; 2. continuing development of a resource wiki; 3. including narratives and classroom video of classroom practice; and 4. creating a modular online text.

Methods & Strategies: 1. Handing off courses to other faculty, both locally and elsewhere; 2. Documenting local classroom practice with video; 3. Expanding and maintaining an extensive wiki containing both individual activities and documentation of entire courses; 4. Expanding and maintaining a modular online text.

Evaluation Methods & Results: Analysis of classroom video; analysis of pre-/post-test data; qualitative student interviews; surveys of beta testers and (former) workshop participants. Student interviews show increased geometric reasoning. Survey results indicate that 1/3-1/2 of workshop participants are using project ideas and materials to a substantial degree.

Dissemination: Several papers in AJP and CMJ on novel approaches to content; faculty workshops at PERC meetings; extensive wiki with worldwide hits; online modular text; numerous invitations to speak at conferences and department colloquia, including several from other countries. Online materials can be regarded as complete, but are being further developed.

Impact: As noted above, 1/3-1/2 of faculty workshop participants make substantial use of project ideas and materials. Favorable student opinion documented through exit interviews of graduating seniors. Faculty interest documented through numerous speaking invitations, both nationally and internationally.
**Challenges:** Our project completely redesigned the upper-division physics major, leading to 18 new courses in a modular class format that is difficult to adopt other than in its entirety. Beginning with this project, our focus shifted from encouraging such global adoption to encouraging and supporting the use of small pieces in a wide variety of circumstances. Such pieces now range in size from individual small group activities to entire courses and even sequences of courses.

**359**  
**PI:** Gerald Feldman  
**Institution:** George Washington University  
**Project Title:** Bridging the Expert-Novice Problem-Solving Gap with the GW-ACCESS Protocol  
**Project Number:** 0837330  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Implementing Educational Innovations

**Goals & Intended Outcomes:** We are developing the SCALE-UP collaborative pedagogy for introductory algebra-based physics classes, incorporating a hierarchical cognitive framework through a problem-solving protocol called ACCESS, which provides a structure for students to improve their problem-solving skills.

**Methods & Strategies:** We follow a similar path as for SCALE-UP in calculus-based classes (designed at NC State by Beichner), but with some modifications for the different population of students (mostly pre-meds). We integrate our ACCESS problem-solving protocol with the elements of the SCALE-UP pedagogy.

**Evaluation Methods & Results:** In the early part of the grant, we have been working on the design of our SCALE-UP and ACCESS hybrid model, including selection and testing of assessment tools. We have tested a variety of assessment instruments, including the Force Concept Inventory, the Lawson Classroom Test of Scientific Reasoning, and the Colorado Learning Attitudes about Science Survey. We had our first major trial in the Fall 2011 semester. Based on results with these tools in our classes, we will refine our plan for executing and assessing the implementation of our model in the Fall 2012 semester.

**Dissemination:** Ultimately, we would like to offer a workshop at an AAPT meeting as a precursor to a larger focused workshop (possibly at GW) for the broader audience of SCALE-UP users across the country. We will report on our preliminary results at the Summer 2012 AAPT Meeting in Philadelphia. We are also preparing a short paper for one of the PER journals, such as Physical Review Special Topics PER.

**Impact:** The implementation of SCALE-UP for algebra-based classes will have a significant impact on many students at GW and around the country. With national reports calling for competency-based curricula for future physicians and life scientists (as opposed to content-driven), the collaborative nature of the SCALE-UP pedagogy is ideal for developing such skills. While SCALE-UP has been deployed at many institutions in courses for scientists and engineers, it is virtually non-existent in algebra-based courses at the present time. Following our initial efforts with SCALE-UP in the mechanics portion of the introductory class at GW, we will be extending our SCALE-UP pedagogy into the E+M portion of the class in the Fall 2012 semester.

**Challenges:** Potential challenges relate to the readiness and willingness of this student population to engage in the collaborative environment. Since class time is spent primarily working interactively with little formal lecture time, there is more of a burden of preparation on the students. This has been successful with the highly motivated science and engineering students in the calculus-based classes, but it has not yet been proven with the algebra-based student population. We have also found that the specific composition of the groups is a sensitive issue in terms of the motivation for students in the collaborative mode and also the appropriate peer support within the student groups themselves.

**360**  
**PI:** Edmundo Garcia-Solis  
**Institution:** Chicago State University  
**Project Title:** Using the Context of Nuclear and Particle Physics for the Integration of Modern Research Techniques into the Undergraduate Physics Curriculum  
**Project Number:** 0941034  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Improving the laboratory experience for our students by using modern research in recruitment and outreach programs.

**Methods & Strategies:** Fostering student interest in science, by training in the use of technology, introducing to the methodology of current experimental nuclear physics techniques. Preparing students for successful collaboration in the research areas of the faculty members in our department.

**Evaluation Methods & Results:** For each developed activity we have prepared pre and post test that evaluate the understanding of the student (or teacher) in the subject. Our evaluations show a significant improvement in the conceptual understanding of the subject of the lab modules.

**Dissemination:** We work with high school students and teachers in regular basis. We organized a summer workshop where we invited 8 teachers from the area.

**Impact:** We have increased the number of students interested in the subject, and facilitated their incorporation to undergraduate research.
**Challenges:** The experimental techniques used in the labs can be challenging for both students and teachers. So we have designed a multistage approach for the modules, from HS to introductory physics courses to advanced physics courses.

**361**  
**PI:** Fred Goldberg  
**Institution:** San Diego State University  
**Project Title:** Developing Large-Enrollment, Guided-Inquiry, Conceptual Physics Course  
**Project Number:** 1044172  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** (1) Develop one-semester large enrollment physics course that engages students in practices of science; (2) implement at three institutions; and (3) studying impact on students’ conceptual understanding and attitudes about physics knowledge and learning physics.

**Methods & Strategies:** Implemented during fall 2011/spring 2012 at one institution, and during fall 2012 at 3 institutions. We developed hands-on lab materials and adapted the online Calibrated Peer Review tool to enable students to construct and evaluate explanations and problem solutions.

**Evaluation Methods & Results:** Designed a conceptual understanding assessment instrument and will use the CLASS instrument for attitudes and beliefs. Both will be administered pre/post. Initial impact data is being collected during spring and fall 2012.

**Dissemination:** We will be presenting papers and posters at AAPT and other conference during summer 2012.

**Impact:** We expect to develop a active-learning curriculum that could have a significant impact on prospective elementary teachers and non-science majors who must take large lecture versions of non-majors physics and who would benefit from a curriculum that engages them in practices of science. Although the class may be large (hundreds of students), students will still experience how physics knowledge is developed and evaluated.

**Challenges:** No challenges yet, as we have just begun implementing curriculum in pilot study.

**362**  
**PI:** Stephen Hagen  
**Institution:** University of Florida  
**Project Title:** An Advanced Laboratory in Biological Physics  
**Project Number:** 1139906  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** The goal is to integrate quantitative life science into the undergraduate physics curriculum. We do this by introducing a research-like biological physics element into a successful, ongoing undergraduate physics advanced-laboratory course.

**Methods & Strategies:** We are designing four new student experiments that combine basic physics and mathematics with important biological ideas and techniques: (1) Brownian motion, (2) optical trapping & biological motors, (3) fluorescence correlation spectroscopy of biomolecules, (4) DNA electrophoresis / elasticity

**Evaluation Methods & Results:** The project is in its first year and we have not yet obtained data. Evaluation will include (1) Student pre- and post-evaluation of learning gains (SALG); (2) Exit interviews with students who take the course and do the biological physics experiments; (3) Feedback from faculty at other institutions. Through collaboration with ALPhA (Advanced Lab Physics Association) we will be hosting immersion experiences in which faculty from other institutions can visit University of Florida, try out the new experiments, and then give us feedback on the intellectual content and merit of the experiments.

**Dissemination:** Dissemination will occur through (1) Posting materials to NDSL and other sci/ed sites; (2) Presentations at national/regional meetings (AAPT /physics teachers and this TUES meeting), (3) ALPhA laboratory immersions (above), which train visiting faculty to teach similar labs at their institutions.

**Impact:** We anticipate that (1) Science students will learn how physics/math/biology ideas are integrated in modern bio/medical research; (2) Our undergraduate curriculum will undergo a big leap into the 21st century by finally recognizing the breadth and important of biological physics, one of the fastest growing areas of physics research; (3) The many undergrads who seek research experience in biological physics will have access to such experience, even though the number of biol/phys PIs in our department is very small.

**Challenges:** This question is premature as the project has just started. But of course we expect the unexpected. We have ample flexibility in our undergrad lab course to modify any element of the project, and we are free to integrate this lab into existing lecture courses (e.g. biological physics course) if that seems like a good approach.

**363**  
**PI:** Robert Hilborn  
**Institution:** American Association of Physics Teachers  
**Project Title:** Enhancing STEM Student Learning Through Faculty Development: Workshops for New Physics and Astronomy Faculty  
**Project Number:** 0813481
| Type: Phase 2/Type 2 - Expansion |
| Focus: Developing Faculty Expertise |
| **Goals & Intended Outcomes:** (1) Reach a large fraction of the physics and astronomy faculty in new tenure-track positions. (2) Help participants develop knowledge about recent developments in physics and astronomy pedagogy and the assessment of changes in pedagogy; and (3) Work with participants to integrate workshop ideas and materials into their classrooms. |
| **Methods & Strategies:** Participants attend four-day workshops with the leaders in physics and astronomy education. The workshops combine experiences with interactive pedagogies and activities focusing on general professional development (grant-writing, time management, mentoring). |
| **Evaluation Methods & Results:** A post-workshop survey addresses the participants' satisfaction with the workshop and their plans for implementing new teaching methods learned in the workshop. An external evaluator follows up with the participants to determine what was implemented and with the participants' department chairs to get information about the impact of the workshop on the participants' teaching and the impact of the participants' work on the teaching culture of the department. |
| **Dissemination:** A workshop on The Role of Scientific Societies in STEM Faculty Workshops will be held on May 3, 2012, associated with a meeting of the Council of Scientific Society Presidents. The report from that meeting will be distributed to all members of CSSP as well as to foundations and other funding agencies. |
| **Impact:** Since their inception in 1996, the Physics and Astronomy New Faculty Workshops have reached over 1400 participants and now bring in about 50% of all new hires in physics and astronomy. Follow-up surveys indicate that the workshop has generally had significant effects on the participants' teaching and on their home departments. |
| **Challenges:** We are continuing to explore ways to stay engaged with the workshop participants as they implement what they have learned in the workshops. We believe that many participants could benefit from continued coaching as they implement changes in their teaching. The use of virtual learning communities and social media are being explored to assist in encouraging continuing interactions among the participants and the workshop leaders. |

364  
**PI:** Andy Johnson  
**Institution:** Black Hills State University  
**Project Title:** Radioactivity by Inquiry for College Science Courses  
**Project Number:** 0942699

| Type: Phase 1/Type 1 - Exploratory |
| Focus: Creating Learning Materials and Teaching Strategies |
| **Goals & Intended Outcomes:**  
1. Learn how to teach radiation and radioactivity to non-science majors so they understand it.  
2. Create inquiry-based course materials that enable conceptual understanding.  
3. Refine the materials via field testing so they are usable in a range of institutions.  
4. Begin disseminating the materials for use by others. |
| **Methods & Strategies:** We are developing the materials through repeated classroom testing and modification. The inquiry is supported by experiments in the classroom and specially designed computer simulators of atomic scale processes. We are also researching learning difficulties to inform our materials development. |
| **Evaluation Methods & Results:** Formative assessments are built into the materials in the forms of ‘initial ideas discussions’, regular classroom discussions, interacting closely with students, and class assignments. We use this data to identify student thinking with additional data from exams and interviews. We have identified and resolved major conceptual difficulties: differentiating types of radiation (EM vs. ionizing), using a mechanistic model of atoms, differentiating radiation from radioactivity, reasoning at both the macroscopic and microscopic levels, and understanding the ionizing effects of radiation. |
| **Dissemination:** We are offering RBI workshops and presentations at summer AAPT meetings (2011, 2012, 2013). Student researchers are presenting their work at NCUR (2011, 2012). We plan to publish papers on our discoveries of learning issues and present at a variety of conferences. We will seek funding to offer RBI training to high school and college teachers nationwide. |
| **Impact:** The RBI materials promote radiation literacy. Students in the testing course show substantial and useful understandings of radiation and atomic scale processes after completing the unit. This helps them in later science courses. We plan to inspire university faculty to try the RBI materials as means to teaching radiation as well as (faculty) learning to use inquiry methods. The project will identify, promote and provide support for portions and key tools of the materials that teachers can effectively use a la carte. The current version of the materials is freely available online with powerful simulators at: http://www.camse.org/radiation. |
| **Challenges:** We did not anticipate the 'undifferentiated view of radiation' learning difficulty. This is a pervasive and persistent view of radiation/radioactivity that is not easily changed. It is a major conceptual difficulty that requires significant instructional intervention, and significant effort on the part of students to
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resolve. We are characterizing the undifferentiated view (http://www.camse.org/andy/posters/diffposter.jpg) and addressing it via multiple interventions throughout the first three cycles of activities. We also lost our Co-PI and had to rearrange field testing plans.

365
PI: Patrick Kohl
Institution: Colorado School of Mines
Project Title: Studio Physics: Understanding and Implementing the Transformation
Project Number: 0836937
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations

Goals & Intended Outcomes:
1. To redevelop the curriculum for an introductory calculus-based physics class to better match the recently-implemented Studio Physics model.
2. To chronicle our secondary implementation of Studio Physics in enough detail to aid other institutions considering a switch to Studio.

Methods & Strategies: We are iteratively rewriting lectures, homework, and Studio activities and assessing the results each semester. Our goal is a unified curriculum that makes use of modern techniques such as scaffolding, wherein difficult tasks are broken into smaller parts with support that is progressively removed.

Evaluation Methods & Results: We have been tracking student performance on exam and homework problems since before the transition to Studio Physics, allowing comparisons over time that strongly suggest student problem-solving performance is increasing and that the male/female performance gap is being reduced. We also give externally-developed and validated surveys pre- and post-instruction. These include the Conceptual Survey of Electricity and Magnetism (CSEM) and Colorado Learning About Science Survey (CLASS).

Dissemination: We have published two papers in the Proceedings of the Physics Education Research Conference, which are archival and peer-reviewed. An additional paper has been accepted by the American Journal of Physics. We have given several invited and contributed talks in a variety of venues.

Impact: The available data show a steadily decreasing DFW (D, fail, withdraw) rate, and evaluations indicate substantially increased student satisfaction in a course that serves 450 students per semester. Approximately forty undergraduate and graduate TAs have been trained in the methods of Studio Physics and have contributed towards the implementation and testing of new activities. Physics has recently been named a model department on campus by the administration, in part because of our demonstrated excellence in teaching introductory courses.

Challenges: The challenges encountered largely matched those anticipated in the grant proposal, with one exception. We had some difficulty retaining hired undergraduate project assistants (distinct from the teaching assistants) for long enough for them to make a meaningful contribution. Aggressive recruiting of top-tier students eventually resulted in some notable successes.

366
PI: Rubin Landau
Institution: Oregon State University
Project Title: Blended, Multimodal Access to Computational Physics Curricula
Project Number: 0836971
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: To encourage wider adoption of computation into undergraduate science education in recognition of computation having become an essential element in science. To develop an eTextBook that permits blended, multi-modal and multilayered access to computational physics curricula materials.

Methods & Strategies: We have created a dynamic, electronic eTextBook that integrates video-slide modules, text materials, interactive programs, and dynamic mathematics into a nearly universal framework. The material are organized around the scientific problem-solving paradigm applied to a wide variety of projects.

Evaluation Methods & Results: We have assessed how the new formats and delivery systems affect the materials' effectiveness for today's learners. Assessments were conducted with students in online classes, and feedback gathered from various schools individuals who have been using our materials. We found that: students used the paper text some 20% of the time; technical problems were rare, 30% of the students made electronic comments, all students thought that the text was essential, 90% of the students though the lecture modules were essential or fairly essential, and that the simulations were essential.

Dissemination: All materials are on line in the OSU Servers. We have placed materials in NSDL pathways: CSERD, Compadre and Merlot. We have taught workshops at AAPT, SCX conferences, and at various schools. We are working with the publisher to develop an eTextBook business model.

Impact: A number of schools have started using the full eTextBook for their courses, as have individuals throughout the country. The lectures are watched multiple thousands of times.
Several publishers have been using our book as a model for future textbooks. We are invited regularly to talk about project and use the opportunity to disseminate materials. Students and faculty do not believe that the entire exetBook is free and online, and so use it as main text and supplement. We have advanced the concept of 'blended' courses. More faculty are looking inside of the computational black box.

### Challenges:
Developing an eBook that can be used widely in a world of rapidly-changing technologies is a big challenge we met via combining markup language elements with web elements, and using nearly-universal multimedia components.

Nevertheless, we have had to create different versions of the materials for PCs, tablets and Kindles. Security issues for operating systems have outlawed 'executable papers', so codes no longer run within pdf. The format for Web technologies keep changing, while some become obsolete. Accordingly, we have changed from MathML to pdf as our base language.

### Goals & Intended Outcomes:
A change in pre-service and in-service teacher education that reflects computation being essential in all sciences. To provide two online/blended courses Computational Scientific Thinking & Modeling for Teachers I, II that teach computing within the framework of solving scientific problems.

### Methods & Strategies:
A collection of modules that can supplement or form the basis for the above courses based upon the scientific problem-solving paradigm now including computation. Materials vetted by computational physicists, Science & Math Educator and biologists located at multiple institutions.

### Evaluation Methods & Results:
Extensive discussion, reviewing and rewriting by the group of a template to be used for all modules as well as the first module. Trial use of developed module in present class for Science Teachers, with group members observing. Survey of students and class teacher after class trials. Materials also to presented at the SC conferences, at biology education conferences, and others. We are assisted by use of communal dropbox and conference calls.

### Dissemination:

### Impact:
Potential impact is to give teachers practical examples for their classes of computation integrated into the scientific problem-solving paradigm, a contextual understanding of the importance of computation, and consequently improved ability to motivate students into science. The under representation of various groups in CS can be improved since it has been found that these students are often not attracted to the hardware and software aspects of CS, but can be drawn to computing after learning that it is an essential ingredient in solving societal problems.

### Challenges:
The greatest challenge is the opposition of students and faculty to the discussion of mathematics, a key component of computation in science. Likewise, and related, the reluctance to use or teach programming. We are dealing with these by providing alternative modes of computation, such as Vensim, Applets and Python codes. The use of language that can be understood by multiple disciplines has also been an issue. Here, careful vetting of the materials and extra explanation of language has been employed.

### 367
**PI:** Rubin Landau  
**Institution:** Oregon State University  
**Project Title:** Collaborative Research: INSTANCES: Incorporating Computational Scientific Thinking Advances into Education and Science Courses  
**Project Number:** 1043298  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

### 368
**PI:** Priscilla Laws  
**Institution:** Dickinson College  
**Project Title:** Collaborative Research: The Impact of LivePhoto Physics Materials and Workshops  
**Project Number:** 0717720  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Implementing Educational Innovations

### Goals & Intended Outcomes:
Video analysis is a potentially powerful tool for helping students master relationships between phenomena and their abstract representations. The LivePhoto Physics team has been studying the impact of the project workshops on teaching practices and on how well students understand projectile motion.

### Methods & Strategies:
The LivePhoto Physics team invited faculty who attended one of 6 workshops [Edmonton 08, Portland 09, Orlando 10, Ann Arbor 10, RIT 09 & 11] to participate in a study relating their teaching practices to student understanding of projectile motion. Dickinson College and RIT faculty were also invited.

### Evaluation Methods & Results:
David Sokoloff (U of Oregon) helped develop a 30 item multiple-choice inventory entitled the Projectile Motion Conceptual Evaluation (PMCE). Our workshop attendees helped refine it. A research kit was developed that outlined procedures for the research project. It was disseminated to participating faculty over a 3-year period.
beginning in Fall 2009. Then Web-based surveys on teaching practices and pre-post PMCE data were collected from over 1200 students in 48 introductory physics courses taught by 25 instructors at 14 institutions. Data is currently being entered and analyzed.

**Dissemination:** A research paper is slated for Fall 2012. Over 2100 copies of our book--Physics with Video Analysis (Vernier, 2009)--have been distributed. Workshop participant Aaron Titus (Highpoint U) and team members plan to offer advanced video analysis workshops at AAPT conferences.

**Impact:** During the 4+ year course of the project, approximately 150 faculty members have attended one of our 6 extended 3-day or 5-day workshops. These faculty members, in turn, have introduced an estimated 3 thousand students to educational video analysis activities. We have worked informally with PTRA leaders and understand that many HS teachers who have attended regional PTRA workshops are also using some of our video analysis techniques and activities.

**Challenges:** The high level of instructor participation in our research project coupled with the impracticality of using scantron forms for PMCE pre- and post-test data entry and analysis have been challenging. Sorting through the Instructor Survey Monkey forms for information on teaching practices and the process of interviewing instructors who have been unusually successful at teaching projectile motion has also been time consuming. However, we are optimistic about our potential to make a significant contribution to the PER literature.

369

**PI:** Kevin Lee  
**Institution:** University of Nebraska  
**Project Title:** Multi-Modal Modules for Learning Introductory Astronomy Concepts  
**Project Number:** 1044658  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** This project will develop a suite of five interactive computer modules for teaching introductory astronomy. The modules will be programmed in HTML5/JavaScript so as to be delivered over the Internet and run on the widest possible spectrum of devices and have a lengthy period of usability. The major focus of the project is really about making effective use of the underlying technology.

**Methods & Strategies:** Each module will contain background information on the topic, a computer simulation that will allow students to explore through a touch interface, and an assessment section that will make use of graphical assessment with superimposed feedback over the question upon grading.

**Evaluation Methods & Results:** There are four modes of data collection. Mode 1 is automatic collection of information about user actions (i.e. time spent, times the quiz is taken, scores, etc.). Mode 2 gathers all student scores and is an aid to instructors (who have distributed their unique code to their students). Mode 3 consists of a short survey for students regarding likes/dislikes, did they feel they learned a lot, any technical problems, etc. Mode 4 is an optional short survey for instructors that will be presented whenever reports of students grades are obtained.

**Dissemination:** We have posted early versions of several modules on our web site which contains other widely-used projects at mature states. Instructors can point students to our site to download the materials and post to their own sites. We plan to teach workshops at national conferences (AAPT, AAS) and post our materials on a publisher’s web site (Norton Publishing).

**Impact:** We anticipate showing faculty and students how mobile devices can be used effectively in education. We all know that mobile devices will be a huge part of our teaching in the future, but we are all a little clueless how to use them in the present. This project will also take full advantage of the data collecting capability that technology provides.

**Challenges:** We are struggling with the extremely rapid pace that technology is advancing. This may turn out to be a positive thing, in that the original proposal specified creating simplistic versions of the modules so that they would run on primitive smartphones. Already our modules work quite well on almost all versions of iPhones and Androids (and Blackberry usage is fading).

370

**PI:** Michael Loverude  
**Institution:** Cal State University Fullerton  
**Project Title:** Collaborative Project: Research on the Teaching and Learning of Thermal Physics  
**Project Number:** 0817335  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Conducting Research on Undergraduate STEM Education

**Goals & Intended Outcomes:**
- Investigate student understanding of key topics in thermal physics
- Develop 15 tutorials and supporting materials on target topics
- Assess & document effectiveness of curriculum and revise as needed

**Methods & Strategies:** Research methods include individual student interviews as well as analysis of student work on written quiz, examination, and homework questions. Instructional
strategies have primarily included in-class guided inquiry worksheets with tasks generated from our research results.

Evaluation Methods & Results: The research on student learning is continuously evaluated internally by the project team through collaborative discussions. Our goal for all work is peer-reviewed publications in journals or conference proceedings. For the curricular materials, we use extensive formative assessment of student learning and make comparisons between response rates pre- and post-instruction. In several cases we have been able to document improvements in student responses after specific modifications to curricular materials, though the small number of students in our target courses means caution is advisable in the interpretation of these results.

Dissemination: We have established a web presence hosting our curriculum and supporting materials as well as a listing in the clearinghouse PER: A User’s Guide. We have worked with a number of faculty at other institutions who have served as pilot testers.

Impact: The curriculum is in use at our institutions and has been tested at a handful of pilot sites. As noted above, our materials are available to potential adopters as well.

Challenges: Perhaps our greatest challenge has come from the structure and nature of upper-division courses and their instructors. We have had relatively few instructors willing to adopt materials wholesale, and fewer still of those were willing to provide us with data on student performance.

371
Pi: Dawn Meredith
Institution: University of New Hampshire
Project Title: Fluids for Life Science Students
Project Number: 1044211
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: Our goal is to gain a better understanding of common student ideas (including both productive and unproductive resources) concerning fluid dynamics. With this knowledge, we will set attainable learning goals and develop curricular interventions appropriate to life science students in intro physics.

Methods & Strategies: We investigate students’ current state of knowledge of fluids using demonstration/simulation interviews. The data will be analyzed to look for common conceptions and productive resources for understanding fluids.

Evaluation Methods & Results: To evaluate the first goal (finding common student ideas and resources about fluid dynamics), we will look for consistency in our data corpus, ensuring that we have data from several students and several contexts in order to claim that we have uncovered ideas that are commonly held. To evaluate the materials we write, we will use pre and post concept tests, checking that students have the correct reasoning as well as the correct answer.

Dissemination: We have not yet begun dissemination.

Impact: The anticipated impact is that the curriculum for fluid dynamics will be more effective than the current curriculum. Data from our own students show that currently students struggle a good deal with ideas of fluid dynamics.

Challenges: There are no unexpected challenges as yet.

372
Pi: Thomas Olsen
Institution: American Institute of Physics
Project Title: Expanding the STEM Workforce by Equipping Physics Graduates and Departments to Fully Engage the Career Options Available to Recipients of the Bachelors Degree in Physics
Project Number: 1011829
Type: Phase 1/Type 1 - Exploratory
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: We seek to learn the effective practices of physics departments that send significant numbers of the bachelor’s graduates into the STEM workforce upon graduation. By disseminating this information with student/faculty workshops and publication, we seek to increase the numbers of physics majors and thereby the number of STEM workforce-prepared students.

Methods & Strategies: We are conducting site visits to campuses with high rates of bachelor’s graduate success in finding STEM employment within a year of graduation. We will disseminate this information through written and on-line publication, and we will hold student/faculty workshops. We also seek to establish a pilot program of alumni career support groups for physics departments.

Evaluation Methods & Results: We have secured an external evaluator to aid us both in the formative assessment of our site visit strategies and practices and to evaluate the effectiveness of our inferences from the site visit reports.

Dissemination: We have a long history of providing career information to students and their advisors at regional Society of Physics Students (SPS) meetings. We will include a major effort to make the work known at the upcoming Sigma Pi Sigma Congress in November, speaking to over 600 physics undergraduates and their mentors. We will use this to kickoff our program of regional workshops.
Impact: We anticipate that as more departments become aware of the practices that have been effective in other departments, some will be adopted. This will continue a process of change, in part sparked by the SpinUP report, that affects the climate and atmosphere of physics departments, embracing all students and all the career paths that they choose. In this evolving atmosphere we expect that more students will opt for the bachelor’s degree in physics and more will enter STEM fields of employment. In addition, we believe this may encourage a more diverse body of physics students.

Challenges: Our primary research tool is site visits to effective departments. To be deemed effective, we have sought departments with a significant number of bachelor’s degrees awarded and a high rate of finding employment in STEM fields. As we generate and examine the site visit reports, it is a challenge to discern which practices lead to significant numbers of majors, which lead to effective preparation for STEM careers upon graduation, and which lead to both. We are looking to our external evaluator to aid us in this analysis.

Dissemination: All of the developed instructional materials and associated publications will be openly available online, as part of a centralized website promoting effective science education. Our work will be presented and promoted at a number of national conferences, and shared directly with other institutions worldwide.

Impact: Although it is too early in our project to assess the effectiveness of these materials and methods relative to traditional modes of instruction, their current implementation has led to overwhelmingly positive feedback from students regarding their usefulness in promoting learning. We anticipate the continued use and refinement of these materials by physics instructors within and outside our department, and the associated research into student learning will inform future efforts at curriculum development and course transformation in physics and other STEM disciplines.

Challenges: Our greatest challenge in developing tutorial activities has been constructing problem statements and diagrams that are unambiguous and easily interpreted by students. Interviews and in-class observations of students interacting with these materials (as part of an iterative process of development, implementation and refinement) have shown that our assumptions about student thinking can often be wrong, and that students themselves are the best judges of clarity.

373
PI: Steven Pollock
Institution: University of Colorado at Boulder
Project Title: Developing Research-Based Tutorials in Upper-Division Electricity and Magnetism
Project Number: 1023028
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Our goal is to develop, refine and disseminate instructional materials that demonstrate improved student learning for a sequence of upper-division undergraduate electromagnetism courses (E&M). This goal is supported by our ongoing research on challenges faced by students in advanced physics courses.

Methods & Strategies: We have established consensus learning goals with faculty input from both within and outside our home institution. Classroom observations, student interviews, and an analysis of student work have informed the creation of instructional materials and assessments that are undergoing an iterative process of refinement.

Evaluation Methods & Results: We are finalizing pre- and post-instruction versions of a research-validated assessment designed to gauge student understanding of topics from upper-division electrodynamics, which has been guided by our explicit learning goals and observations of student difficulties. This assessment has been vetted by physics faculty outside our PER group, and will be used in a variety of course settings to determine its usefulness and reliability. We are also gathering data through post-instruction student surveys on their perceptions of the effectiveness of the instructional materials and their implementation.

374
PI: Travis Rector
Institution: University of Alaska Anchorage
Project Title: RBSE-U: The Implementation of Research-Based Science Education in Astronomy for Undergraduates
Project Number: 920293
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: We are implementing our ‘Research-Based Science Education’ (RBSE) curriculum at six institutions. The goal is to engage ‘astro 101’ students in authentic research. The purpose is to improve understanding of the process of science, critical thinking skills, and attitudes towards STEM careers.

Methods & Strategies: Six partner institutions (two ‘research one’ universities, two teaching-focused, four-year universities, and two community colleges) are implementing the RBSE curriculum in their introductory astronomy classes. They are being tested in a variety of teaching situations and student demographics.

Evaluation Methods & Results: Student gains in understanding the process of scientific research are being measured with concept maps wherein students are given a fixed set of terms related to research (e.g., ‘experiment’, ‘results’ and ‘publication’)
and the quality of their links between these terms are measured. Our results indicate the biggest gains are in understanding that research is an iterative loop wherein current research is informed by past work, and influences future projects. Student gains in critical thinking are being measured using the Critical Assessment Tool (CAT). These will be scored this summer.

**Dissemination:** Our RBSE curriculum is available on our website and our results have been presented at several conferences. We have attracted several additional users of our curriculum from these presentations. Future dissemination will hinge on our ability to make the projects easier to use via online analysis tools.

**Impact:** Students have made the largest gains in understanding: (1) that research is a lengthy process (i.e., a series of many steps over time), (2) it is an iterative process, where new results inform future research, and (3) that scientific research is the discovery of new knowledge, not the learning of established knowledge (i.e., a literature search). Students made the least gains in understanding that (1) research involves equipment (e.g., telescopes), and (2) data collection. This latter part is not surprising, as students do not collect their own data but instead use data from prior observations or data archives.

**Challenges:** The single largest unexpected challenge has been technical issues associated with implementing the projects at parter institutions. All of the projects currently require that software be installed on lab computers and data sets be downloaded either from online or DVDs. At the start of the project, one partner institution eliminated all of its computer labs. And at two others there have been significant challenges with installing the software and datasets reliably on netbooks. For this reason we are planning to develop online data analysis tools that allow us to overcome these implementation barriers.

**375**

**PI:** Edward Redish  
**Institution:** University of Maryland  
**Project Title:** Collaborative: Research: Creating a Common Thermodynamics  
**Project Number:** 1122818  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  

**Goals & Intended Outcomes:** The primary goals of our project are to understand the commonalities differences in the way thermodynamics is conceptualized and taught in physics, biology, and chemistry and to create a set of curriculum materials including text, homework problems, and in-class activities that bridge the traditional approaches in the three disciplines. In addition, we will complete a literature review on the concepts of thermodynamics, including entropy and energy, from across the chemistry, biology, and physics education literatures.

**Methods & Strategies:** The methods we use to inform our developments are drawn from three sources. Weekly Skype conversations among the participants address particular thermodynamic issues and compare disciplinary perspectives. Information gleaned from the literature survey helps identify the essential conceptual reasoning the curriculum should address and the most probable student confusions and errors. In addition, we video-record in-class activities, collect student reading responses, homework, quiz, and exam data, as well interview current students on problem-solving tasks developed and their views and attitudes about the consistency of what they are learning about thermodynamics in physics, chemistry, and biology classes.

**Evaluation Methods & Results:** The evaluation methods used for the curriculum design include both formative and summative assessments. Formative assessments include understanding the reasoning process students use in problem-solving interviews, analyzing in-class tasks using research designed rubrics, inter-rater reliability, and comparison of results from the literature base. Summative assessments beyond quiz and exam data include the development of items focused on thermodynamics on a conceptual inventory survey.

**Dissemination:** The project has been invited to disseminate the results of its literature review through a resource letter on thermodynamics for the American Journal of Physics. Further, the project is part of a larger project developing a full-year curriculum for life science majors. As part of this project the activities developed on the common thermodynamics project will be disseminated to other universities working on physics courses for biologists. We are also disseminating results through published papers and conference proceedings (6 as of April 2012) and through invited talks and contributed presentations at conferences and universities (16 through August 2012).

**Impact:** At this point in the curriculum, we have preliminary evidence to suggest the focus on a common thermodynamics has impacted students such that they feel comfortable leveraging resources from outside the class to reason about physics. Further, regular meetings between disciplinary experts across the university have created a focus of collaboration that is anticipated to impact the connections between the disciplines.

The project will impact the department directly in its second iteration of the curriculum, in which an additional section of the course will be run by a biophysics professor from within the department.

**Challenges:** One challenge that was in part anticipated was the large difference in language and concepts used across the disciplines. The project anticipated these differences and made provisions for disciplinary experts to meet regularly to discuss
these issues. These meetings became essential when the project moved into the realm of teaching bond energy, entropy, and Gibb's Free energy.

376
Pl: Eleanor Sayre
Institution: Kansas State University
Project Title: Collaborative Research: Developing a Tool for Teachers to Assess Real-time Learning and Forgetting in Large Classes
Project Number: 1240782
Type: Phase 1/Type 1 - Exploratory
Focus: Assessing Student Achievement

Goals & Intended Outcomes: We designed and built a web-based system for tracking student understanding in introductory physics classes. The system tests different students every week throughout the year on conceptual and procedural topics in physics, as well as fundamental ideas undergirding physics understanding (like vectors or epistemologies)

Methods & Strategies: We use a between-students design to sample students on each task, subject to the following constraints: each student takes a task every week; each student sees each task only once; each task is tested every week. Tasks are drawn from classical PER tasks and validated through student interviews.

Evaluation Methods & Results: The student and instructor interfaces with the system will be evaluated through interviews with students and faculty (respectively), and with system data such as time-on-page and other interactions with the system. These interviews will take place simultaneously with additional interviews to validate tasks.

Dissemination: We have published five peer-reviewed conference proceedings, one peer-reviewed journal paper, and about 20 contributed talks or posters. We are presenting a workshop at the National Meeting of the American Association of Physics Teachers in August, and plan an additional 2- to 4 papers to be submitted in the next year.

Impact: The project has mentored nine undergraduate researchers, two of whom have gone on to graduate school (the others are still undergraduates). The entire introductory sequence at the Rochester Institute of Technology (PI Franklin's institution) participates in the online system. Beta-testers at USMC West Point include several thousand students. Additionally, we have partnered with researchers at other institutions to develop tasks, serve them to students, and analyze the resulting data.

Challenges: Both PI Sayre and Evaluator Dancy changed institutions (from Wabash College to Kansas State University and from Johnson C Smith University to the University of Colorado at Boulder, respectively) during the grant period, which has led us to do more development work on the online system earlier and evaluation work later.

Additionally, this has changed our opportunities to recruit institutions for beta-testing. We started taking beta-test data at West Point and have started a relationship with the University of Central Florida which may result in additional testing in the fall.

377
Pl: Michael Schatz
Institution: Georgia Tech
Project Title: Transforming Homework into Cyberlearning in an Introductory STEM Course
Project Number: 0942076
Type: Phase 1/Type 1 - Exploratory
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Develop methods for integrating computational modeling into introductory STEM courses.

Methods & Strategies: Development, testing and assessing computational homework problems/exercises for an introductory physics course that can be delivered online via standard course administration tools.

Evaluation Methods & Results: Proctored assignments, think aloud protocol interviews.

Dissemination:
• presentation of results at regional and national meetings
• website containing preprints/reprints.
• sharing developed materials with anyone who is interested.

Impact: My faculty colleagues show great interest in using computation in introduction STEM courses.

Challenges: None.

378
Pl: Scott Schultz
Institution: American Association of Physics Teachers
Project Title: New Faculty Workshop for TYC Physics Faculty
Project Number: 0940857
Type: Phase 1/Type 1 - Exploratory
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: The goal of the project is to improve undergraduate physics education by developing the expertise of new faculty teaching physics at two-year colleges. We seek to develop mentoring relationships as well as peer-to-peer relationships that will sustain the efforts of the new faculty implementing the change.
**Methods & Strategies:** The project provides an 18-month experience to 28 new faculty. The experience consists of online discussions of seminal papers in physics education research, a 4-day conference on active engagement strategies, online collaboration and mentoring for 16 months followed up with a commencement conference.

**Evaluation Methods & Results:** We collected data on the initial state of the new faculty that are involved in the project through an assessment developed and delivered online. The new faculty have been engaged online and we have been monitoring their discussions looking at both quantity and quality of posts. Each faculty member will be required to submit a portfolio of their work completed during the experience, present a paper at the commencement conference and take an exit online survey to assess their growth throughout the project.

**Dissemination:** We have an entire session at the summer meeting of the American Association of Physics Teachers devoted to the project. At this session we will have speakers ranging from the PI, to other content leaders/mentors to the actual participants. In addition those participants not giving an oral paper at the national conference will be presenting a poster at the commencement conference which will stay up for the national AAPT conference.

**Impact:** We expect that the new faculty will have made significant change and that we will have moved them along far enough that the change will be sustained through the future. It is also our intention to help them fully integrate into the profession by guiding them through a national meeting, helping them to network with other physics instructors and sharing with these new faculty the opportunities for professional development available at the conclusion of the project.

**Challenges:** The problem we have is keeping the participants involved in the project throughout the entire 18-month experience. We had one participant cancel days before the start and we were not able to fill that opening. We had another one get sick while traveling to the main conference and returned home without attending. We had a third participant go on maternity leave and miss an entire semester of work and they have completed less work than the rest of the participants.

**PI:** Chitra Solomonson  
**Institution:** Green River Community College  
**Project Title:** Introducing Research Experiences at Community Colleges  
**Project Number:** 1141339  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies  
**Goals & Intended Outcomes:** The goals of the project are to improve the quality and capacity of the STEM program at Green River Community College (GRCC). The outcomes include improved student attitudes towards STEM, development of research and inquiry skills through Inquiry Lab Modules in a cutting edge field like Organic Photovoltaics, and greater transferability from two year to four year schools.

**Methods & Strategies:** GRCC will be developing research-like labs called Inquiry Lab Modules (ILMs) in collaboration with the University of Washington (UW) that will enable students to explore key concepts using specialized equipment located at GRCC and the UW. The ILMs will be pilot tested by a few GRCC students and field tested in one class before being incorporated in the curriculum at GRCC.

**Evaluation Methods & Results:** The external evaluator will administer the SURE and CURE surveys to evaluate students’ attitude and understanding of STEM fields, eagerness to pursue STEM careers, likelihood of pursuing higher degrees in STEM fields and the self-reported ability to conduct inquiry based activities before and after working with the ILMs. The evaluator will test the students on the ILM content, interview faculty who take part in the summer training for ILMs and those who decline. Faculty will complete a post-workshop survey, rating their understanding and confidence in implementing the ILMs in their own classes. Since the first pilot test for the ILMs will only be in January, no implementation results are available but a rough draft of the ILM will be ready at the time of the conference.

**Dissemination:** The ILMs will be adopted by the Physics department at GRCC. Ten community college faculty members will be invited to attend a workshop hosted at GRCC to receive training to implement ILMs at their own institutions. ILMs will be presented at national meetings. The ILMs will be posted on a Photonics wiki that is already viewed widely (48,000 unique visitors at last count).

**Impact:** Transferring to a four year school is becoming more competitive. More and more students are entering community colleges on their way to earning a four year degree and competing for fewer and fewer seats. Getting involved in research early in their education will help community college students develop the skills they need to be competitive and to stay in their chosen STEM field. Physics (and possibly other Science) faculty at Green River will adopt ILMs in their curriculum. Collaboration with the UW will open up new opportunities for community college students to visit research labs, do projects in cutting edge fields with sophisticated equipment and continue their work after they transfer. In the long run, this could serve as a model of collaboration between any community college and a four year university.

**Challenges:** Without having started the project, it is difficult to talk about unexpected challenges but there are some challenges that could arise. The PI will develop ILMs with the resources provided by the UW which will then be implemented at GRCC. Integrating the ILMs in the existing curriculum and housing the
equipment in a limited space will be a challenge at GRCC. The PI has addressed this by hiring a curriculum developer who is a highly effective and experienced Physics instructor (and Science Division chair) at the community college. The PI is working with the administration to find space to house the equipment near the Chemistry lab which will also provide access for Chemistry students to these projects.

380

PI: Robert Teese
Institution: Rochester Institute of Technology
Project Title: Collaborative Research: LivePhoto Physics Interactive Video Vignettes
Project Number: 1122828
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies

Goals & Intended Outcomes: Interactive Video Vignettes represent a new genre of learning materials. As we create them, we are conducting research about their impact on student learning and attitudes. This will inform other developers' efforts to create interactive learning materials in many disciplines.

Methods & Strategies: We are creating and evaluating a series of Interactive Video Vignettes - short single-topic video expositions that incorporate student measurement and analysis activities. These web-based vignettes are being designed to supplement textbooks and serve as ungraded pre-class or pre-lab activities.

Evaluation Methods & Results: Interactive Video Vignettes are being classroom tested at RIT, the University of Cincinnati and Dickinson College. Data on how students interact with vignettes is tracked automatically and compared to information gathered in class. We will identify and isolate learning gains resulting from student use of vignettes; document misconceptions encountered in student interactions with vignettes; and learn about the efficacy of techniques for motivating students to complete vignettes.

Dissemination: Before the award we gave a presentation at an American Association of Physics Teachers national meeting. We will give other presentations and workshops, submit publications, and offer vignettes free of charge to textbook publishers. Vignettes will be available through ComPADRE and the NSDL.

Impact: Web-based vignettes can have similar benefits as simulations do while having some benefits of real experiments. Vignettes are being designed to help students overcome common conceptual difficulties while enriching their understanding of scientific knowledge construction. We are developing new techniques for web-based educational research that can provide information on misconceptions, data interpretation problems, and instructional strategies that optimize student use of the vignettes.

Challenges: We were aware that eventually vignettes would need to be modified for use with iPads and other mobile devices, but we were surprised by the rate at which new devices are being adopted. We asked a team of software engineering seniors to begin working on the new technologies in the Fall of 2011 (six months earlier than in our proposed timeline), and by Mid-Spring of 2012 they had a vignette ready for classroom testing.

381

PI: John Thompson
Institution: University of Maine
Project Title: Collaborative Research: Research and Curriculum Development in Thermal Physics
Project Number: 0817282
Type: Phase 2/Type 2 - Expansion
Focus: Conducting Research on Undergraduate STEM Education

Goals & Intended Outcomes: Our overall objective is to probe physics students' reasoning from introductory through more advanced courses, and to use this research as a basis for developing improved instructional methods and materials.

Methods & Strategies: Data are gathered using one-on-one student interviews, written pre- and post-test questions, and multiple-choice surveys. The research is then applied to the development of active-learning student-centered curricular materials intended to improve student understanding.

Evaluation Methods & Results: We have identified several specific student difficulties with concepts in thermal physics. We have extended our work to investigate student understanding of, and difficulties with, the prerequisite and underlying mathematics concepts and their application to the physics. We have developed student-centered instructional materials across thermodynamics and statistical physics - and the related mathematics - that we have evaluated using written pre- and post-tests, video of students working through them, and individual student interviews. Most are successful, and all have been iteratively modified.

Dissemination: We have solicited instructors who are colleagues; we have been contacted by instructors who have seen presentations or read published articles; and we have put materials up on a website.

Impact: Students have a deeper conceptual understanding of the physics content, and, arguably, a better sense of how the mathematics applies to the physical situations and how the physics 'becomes' the mathematics. Our department has more examples of student-centered instruction beyond the
introductory courses. We anticipate additional benefits as more institutions adopt our materials.

**Challenges:** Coordinating research and pilot-site implementation across several institutions and keeping track of the pilot sites, and maintaining the latest versions of materials. Making sure instructors understand the expectations for the use of the materials. We dealt with this by trying to assign one person to communicate with external personnel, but this was not always successful.

### 382

**PI:** Ralf Widenhorn  
**Institution:** Portland State University  
**Project Title:** Physics in Medicine: Active Learning Tools for Undergraduate Physics Courses Developed in a Joint Collaboration of STEM Scientists and Medical Experts  
**Project Number:** 1141078  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Creating Learning Materials and Teaching Strategies

**Goals & Intended Outcomes:** Physics in Medicine is part of a broader initiative to emphasize the link between physics and the life sciences. The resulting material will be modular and can be used as a whole curriculum in a specialized Physics in Medicine course or in part as supplement in introductory general physics.

**Methods & Strategies:** Course material, which includes worksheets for hands-on activities, discussions, and homework assignments, will be developed in a collaboration of professors at the PSU physics department, the OHSU School of Medicine, and consultants from their field of expertise.

**Evaluation Methods & Results:** We will develop both formative and summative assessment measures for the project. The assessment measures include a pre-post knowledge tests that students will complete before and after each of the six modules; a memory matrix and minute paper for use during the modules. The pre-knowledge test will provide formative feedback to the instructor and the post-knowledge test will provide summative information. Course assessments will be disseminated along with course materials.

**Dissemination:** The material produced will be disseminated through the PSU Physics in Medicine Course website, private industry partners (Vernier or NI), and educational websites like Compadre. Reports on learning outcomes and pedagogy will be prepared for a minimum of two peer-reviewed physics journals and two physics education conferences.

**Impact:** The potential success of the elective one-term Physics in Medicine Course will be the foundation for an even bigger overhaul to revise the pre-medicine physics curriculum to prepare pre-medicine majors for the rapid advancements in medical technology. A long-term goal would be the integration of the medical physics elements into an expanded three-term course that incorporates general physics with medical physics. We want to form a community of educators, researchers and professionals in both physics and the medical field. This project has already connected a larger number of individuals from the medical school (OHSU) and PSU where students take the prerequisites for medical school.

**Challenges:** We are still early in the project, but the start has been very encouraging. My collaborators and students are very engaged and motivated. The biggest unexpected challenge so far is the logistics. Scheduling meeting times that work for everybody and keeping everybody updated and on the same page can be difficult. Making sure that there remains enough time to devote on the content of the project can be a challenge. We are using online tools like Dropbox, Google Docs, and Doodle to manage some of these tasks.

### Research or Assessment

### 383

**PI:** Lei Bao  
**Institution:** Ohio State University  
**Project Title:** Developing Scientific Reasoning Assessment Tools for STEM Education and Teacher Preparation  
**Project Number:** 1044724  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Assessing Student Achievement

**Goals & Intended Outcomes:** Develop an instrument for assessment of the scientific reasoning skills of teachers and students at high school and college levels. Study the developmental characteristics of scientific reasoning skills.

**Methods & Strategies:** We use mixed methods including both qualitative interviews and quantitative assessment to develop and validate the assessment instrument.

**Evaluation Methods & Results:** We conduct interviews and use the qualitative data to establish the validity of the assessment instrument. We use large scale quantitative assessment data to study the psychometric characteristics of the assessment items. The results also help to further establish the reliability and validity of the instrument.

**Dissemination:** We have developed a project website and have distributed materials to interested teachers and institutions through professional conferences and social community networks such as teachers’ mailing lists, etc. We will continue this effort and will also integrate the materials into PD programs.

**Impact:** The product of the project (assessment instrument on scientific reasoning) is still under development. Students, teachers, and faculty who learned about this project through
different channels (such as Google search) have expressed strong interests in using this tool in their teaching. Once finished, we will more aggressively disseminate the product and we expect that many professional development programs will start to adapt this instrument into their education plans.

Challenges: We have not encountered any unexpected challenges.

384
PI: Mark Connolly
Institution: University of Wisconsin-Madison
Project Title: Impact of Professional Development Programs on Future STEM Faculty: A Mixed-Methods Longitudinal Study
Project Number: 0817537
Type: Phase 3/Type 3 - Comprehensive
Focus: Developing Faculty Expertise

Goals & Intended Outcomes: Our five-year study explores the preparation of future STEM scholars for their role as undergraduate educators. Specifically, we are examining the short- and long-term effects of future-faculty professional development (FFPD) programs on STEM doctoral students and their early-career performance.

Methods & Strategies: The study uses a longitudinal, mixed-methods design. One group of doctoral students was surveyed in Years One (N=2163) and Three (N=2011) of the study, and will be surveyed again in Year Five. A subsample of this group (N=75) were interviewed in 2011, and will be interviewed again in two years.

Evaluation Methods & Results: Because our award is for a research study and not a TUES project per se, we have not conducted any kind of program evaluation activities. We do, however, rely upon the guidance and feedback of our national advisory board. Because of changes in project personnel last fall, we did not hold our third annual advisory board meeting, but we are planning to resume this practice this coming October. We also are planning to add several members who provide particular kinds of expertise of value to our project.

Dissemination: Findings from this study have been disseminated thus far primarily via professional conferences in both the US and the UK. These meetings include the American Educational Research Association (AERA) and the Professional and Organizational Development Network in Higher Education (POD). Findings were also presented at Oxford University’s Center for Excellence in Teaching and Learning (CETL) and at the CIRTL Forum in Madison, WI. We will continue to present research papers to various research conferences, including upcoming meetings of the Association for the Study of Higher Education (ASHE), the American Educational Research Association (AERA), the Midwestern Association of Graduation Schools (MAGS), and the TUES/CCLI PI Conference. In addition, we will submit conference papers to peer-reviewed journals and develop a series of research briefs to reach graduate students, faculty advisors, and administrators.

Impact: Our findings about types of future-faculty professional development programs will assist with designing and evaluating other such programs. Our findings on the differences between participants and non-participants as well as barriers and supports to participation will be important to faculty advisors and graduate students. Finally, our longitudinal perspective on study participants’ academic choices and early-career performance as educators of undergraduates will make important contributions to both policy and research on doctoral education.

Challenges: The most significant project challenge during the reporting period has been the significant variation in teaching development programs across the study’s three participating institutions. This diversity makes classifying the programs as standardized ‘treatments’ unexpectedly difficult; however, this classification is essential to making apples-to-apples comparisons across institutions that would reveal any differential program effects.

385
PI: Charles Henderson
Institution: Western Michigan University
Project Title: Collaborative Research: Increasing the Impact of TUES Projects Through Effective Propagation Strategies: A How-To Guide for PIs
Project Number: 1122446
Type: Central Resource Project
Focus: Implementing Educational Innovations

Goals & Intended Outcomes: The purpose of this TUES Central Resource Project is to help TUES PIs, as well as other educational researchers and curriculum developers, increase the impact of their projects through increased focus on project design and strategies to facilitate wider adoption/adaptation of new learning materials and teaching strategies.

Methods & Strategies: This project will work to improve propagation strategies within the TUES community through four core activities:

1. Collect propagation strategies used by current and former TUES/CCLI projects to promote adaptation and implementation of innovative developments in STEM education.
2. Analyze and categorize strategies and success of projects in terms of empirical evidence and factors identified by theories of change.
3. Promote discussion about and awareness of the importance of deliberately designing propagation
strategies and explicitly using appropriate strategies in project planning.

4. Develop accessible resources about a range of possible propagation strategies as well as how to identify and optimize strategies to enhance impact. These resources will be in the form of three interventions that collectively will reach over 700 TUES proposal authors: A) written how-to guide, B) webinar presentations, and C) individual consultations.

**Evaluation Methods & Results:** Five basic evaluation activities will be employed in this project: 1) collection of data about the number of users of the interventions; 2) collection of data from intervention users about their perception of the quality and impact of the interventions; 3) targeted feedback from three separate panels of relevant stakeholders; 4) general and targeted feedback from an advisory committee of four individuals with diverse expertise; and 5) peer review of publications and presentations.

**Dissemination:** Dissemination is built into the project design. Significant dissemination activities include: 1) Panel meetings. 24 current/former TUES PIs and other relevant stakeholders, on three separate panels, will spend a day discussing propagation strategies. 2) The three interventions. The how-to guide and webinars are expected to reach 450 and 225 people respectively during the project lifetime and will be available indefinitely after the project period ends. In addition, we will offer individual consulting with approximately 30 potential TUES PIs.

**Impact:** We expect that this project will have the impact of creating discussion, emphasis, and new knowledge related to propagation of proven learning materials and teaching strategies. Developing ways for TUES PIs, during the project planning stage, to have access to lessons learned and strategies that have been successfully used by current and former TUES PIs will improve the dissemination activities of TUES PIs.

**Challenges:** The project has only been running for 3 months (as of this writing). Thus, we have no unexpected challenges to report.

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**386**

**PI:** Adam Maltese  
**Institution:** Indiana University  
**Project Title:** Undergraduate Scientists: Measuring the Outcomes of Research Experiences from Multiple Perspectives (US-MORE)  
**Project Number:** 1140445  
**Type:** Phase 1/Type 1 – Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education  
**Goals & Intended Outcomes:** We seek to build a foundation of understanding of the many variables that influence student outcomes for undergraduate research experiences, both short- and long-term, and the range of meaning they have for students and mentors. Based on findings from this initial study, we seek to develop instruments that can be used to assess (and validate) the levels of gains made by students for the most common outcomes.

**Methods & Strategies:** We are using a combination of qualitative interviews and observations and quantitative survey data to understand student outcomes. We are collecting these data from students, mentors, faculty advisors, program administrators and program alumni in an attempt to triangulate reports of outcomes from multiple sources.

**Evaluation Methods & Results:** This project is essentially a more detailed evaluation of undergraduate research programs than is commonly done at most sites, thus we do not have a specific evaluation, per se. We do have a set of expert advisors from chemistry, physics and science education who provide project guidance and feedback on the analysis of our results to help us put them in the proper context.

**Dissemination:** We are in data analysis phase after our first round of data collection from URE/REU programs in summer 2012. We submitted multiple proposals to education research conferences and will soon work to prepare these for submission to journals.

**Impact:** Given that the project is still in its early stages, our results have not had any effect yet beyond feedback for URE/REU program leaders who are participating in our project. We anticipate that our results may indicate best practices toward getting students to consider careers in STEM and begin the process toward establishing standardized measurement tools to measure student gains across undergraduate research programs.

**Challenges:** Currently the biggest challenges are soliciting research teams to participate from a variety of contexts and maintaining consistent data collection across multiple sites.

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**387**

**PI:** Ross Nehm  
**Institution:** Ohio State University  
**Project Title:** Collaborative Research: Educational Assessment Tools for Genomics and Bioinformatics Education  
**Project Number:** 0837397  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Assessing Student Achievement  
**Goals & Intended Outcomes:** The overarching goal of our research is to build a new assessment of genomics and bioinformatics content knowledge that meets appropriate quality control criteria. Our study involves (1) analyzing the current literature; (2) establishing the content domain; (3) using experts to corroborate the domain boundaries; and (4)
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designing and psychometrically evaluating items that align with the domain.

**Methods & Strategies:** Several different methods were used in our study: (1) A content analysis of more than 200 articles; (2) a study of textbooks (n=5); (3) a survey of 59 experts' views of the content domain; and (4) a multidisciplinary assessment design panel (biologists and educational measurement specialists).

**Evaluation Methods & Results:** Our content analysis of the literature revealed limited reporting of validity or reliability evidence in prior work in genomics and bioinformatics education, calling into question the robustness of study findings. We also created a survey to determine the conceptual relatedness of the fields of genomics and bioinformatics. In addition, 29 subtopics were proposed as candidates for representing these domains by consulting a panel of genomics experts (n=59) and by surveying genetics, genomics, and molecular biology textbooks for content coverage. We found that genomics and bioinformatics were envisioned by experts as overlapping disciplines and also found strong support for inclusion of 26 of the 29 subtopics.

**Dissemination:** The content analysis of the genomics and bioinformatics literature was presented at last year's SABER conference and in a manuscript nearing completion. The content validation work was presented at NARST and published on the conference CD. The item development process is currently in progress.

**Impact:** The results of our content analysis shed light on the lack of attention to measurement quality control benchmarks in genomics and bioinformatics education research. This finding highlights the urgent need for biology educators to become aware of these benchmarks as well as the need for biology education journals to enforce basic standards of educational measurement. Our attempt to establish the content domain for genomics and bioinformatics is the first of its kind. We have provided a list of subtopics, with strong support from expert biologists, and are currently developing items that align with these topics.

**Challenges:** We anticipated that the large literature (n > 200 articles) in genomics and bioinformatics education would have defined the content domain(s) of genomics and bioinformatics. Our finding that no attempt has been made to establish what topics do and do not represent this domain required a large amount of basic work that should have been done previously. We fear that other topics in the New Biology have avoided the basic but crucial task of construct delineation.

**SOCIAL SCIENCES**

**388**

**PI:** Andrew Beveridge  
**Institution:** Queens College and Graduate Center CUNY  
**Project Title:** Creating and Disseminating Tools to Teach with Demographic Data Maps and Materials  
**Project Number:** 0919993  
**Type:** Phase 2/Type 2 - Expansion  
**Focus:** Creating Learning Materials and Teaching Strategies  
**Social Sciences Discipline:** Sociology

**Goals & Intended Outcomes:** Social Explorer was conceived to build the most informative and easiest-to-use demographics website in the world. Curricular materials have been developed and research has been conducted to understand how users learn using such materials. The website transforms users into demographic researchers with just a few simple clicks.

**Methods & Strategies:** Easy-to-use online tools give users access to a wealth of data and the ability to create customized maps without the need for sophisticated training or laborious data analysis software. By breaking down these barriers and making data and maps easy to work with, Social Explorer has opened up demographic and social research to students, researchers and others across the disciplines. A new version of the tool is being developed to more directly support instruction.

**Evaluation Methods & Results:** Among other things, our evaluation has included using log files of use, related to outcomes; as well as both formative and summative evaluation in the class room. We also are working to understand how students and others use and understand the sort of quantitative data that underpins Social Explorer. We are also exploring learning sequences, and have begun to develop strategies to make it possible for students to relate to the data personally, while understanding the results of their 'explorations.'

**Dissemination:** Over 250 university and other libraries subscribe through a distribution partnership begun in 2010 with Oxford University Press for a Professional Edition. In 2009, Social Explorer began collaborating with Pearson Publishing to develop a Student Edition used with 22 sociology textbooks, including the top two selling introductory sociology texts. The agreement was so successful that in the renewal data and maps for Political Science and History will be added. Currently there are more than 15,000 registered users of the student edition.

**Impact:** Social Explorer helps users learn who lives where, how communities compare, what has changed over the decades and centuries, and so much more. In March 2012, over 37,000 unique visitors created over 600,000 maps and reports. In 2010, Social Explorer was named an 'Outstanding Reference Source' by the Reference and User Services Association (RUSA), a division of the American Library Association. (Social Explorer
was the sole online-only research tool featured among the awardees.)

**Challenges:** Since our goal has been sustainability, we wanted to move the IP outside of CUNY and work to get patent and trademark protection. This is a very complex process. So far we have been successful, but we have as yet not attained sustainable finances, that would enable us to continue to expand and update the demographic data, and add other data to the applications. This may be possible with our agreements with Pearson, Oxford and the New York Times.

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### 389

**PI:** William Frey  
**Institution:** University of Michigan  
**Project Title:** Infusing Quantitative Literacy Throughout the Social Science Curriculum  
**Project Number:** 0816517  
**Type:** Phase 3/Type 3 - Comprehensive  
**Focus:** Creating Learning Materials and Teaching Strategies  
**Social Sciences Discipline:** Multi-disciplinary

**Goals & Intended Outcomes:** This project aims to transform teaching in the social sciences by infusing quantitative literacy throughout the curriculum and by providing undergraduates active experiences with the most advanced social science data. With greater quantitative literacy, we expect these students will be stronger critical thinkers.

**Methods & Strategies:** This project is working with a group of social science faculty from institutions across the country to evaluate and disseminate learning activities and assessment tools. We are also committed to providing professional development to instructors through workshops and online webinars.

**Evaluation Methods & Results:** Our evaluation methods included a survey with follow-up interviews of social science faculty to identify barriers to the use and re-use of online resources to support the use of quantitative data in the undergraduate classroom. Instructors involved in the project also obtained multiple measures of impacts on student learning and confidence analyzing quantitative data.

**Dissemination:** Through the efforts of our project, we have authored a workbook, performed several webinars and workshops, and created a website in collaboration with Carleton College’s Science Education Resource Center to disseminate materials developed through this project. We have also made these available through NSDL.

**Impact:** While there is still much to analyze, early evaluation has shown that students are increasingly confident and comfortable working with quantitative information following only several opportunities for exposure. Similarly, faculty who have participated in our workshops and webinars have reported that they are comfortable integrating quantitative literacy learning activities in their non-methods courses afterward, particularly with American Community Survey Data.

**Challenges:** While we had hoped to create a single tool that could be used to assess and evaluate student learning for a variety of learning activities, the reality was that this is too difficult to achieve with such diverse set of learning activities and associated outcomes.

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### 390

**PI:** Edna O. Schack  
**Institution:** Morehead State University  
**Project Title:** Collaborative Research: Noticing Numeracy Now  
**Project Number:** 1043656  
**Type:** Phase 1/Type 1 - Exploratory  
**Focus:** Conducting Research on Undergraduate STEM Education  
**Social Sciences Discipline:** Mathematics Teacher Preparation

**Goals & Intended Outcomes:** To determine the extent to which an innovative learning experience focused on the professional noticing of children’s numeracy develops PSETs’ capacity to attend to, interpret, and respond appropriately to the mathematical thinking of individual children. We intend to answer three research questions.

**Methods & Strategies:** A researcher-developed module focused on professional noticing in the context of early numeracy & using the pedagogies of practice is implemented at 5 institutions. Preservice teachers participate in pre and post assessments and module. The module consists of in-class sessions, homework, and interview task.

**Evaluation Methods & Results:** Pre and post assessments consist of 1) video case professional noticing measure, 2) LMT/TKAS, and 3) Attitudes Toward Mathematics Inventory. Preliminary results for the video case professional noticing measure at three institutions indicate statistically significant growth of professional noticing skills as a whole. A separate one-way ANOVA on each of the PN skills (attending, interpreting, deciding) demonstrates the module and instructors contribute 15% of growth in attending & interpreting and 30% of growth in deciding.


**Impact:** The preliminary data indicate that preservice teachers participating in the first semester implementation were
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positively impacted in terms of their professional noticing. A faculty member implementing at one institution, but not involved in the development of the module, reports being able to readily use the module in her course and have a positive experience. While the PSET outcomes at this site remain to be analyzed, we have cautious optimism for the scalability of the module.

Challenges: The culminating experience of the module is the implementation and analysis of a diagnostic interview by PSETs. The challenge in this has been gaining consistency among the universities despite the diversity and timing of field experiences at each university. The assignments are not identical, however, PSETs are expected to participate in the practice of diagnostic interviewing and apply professional noticing skills.

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PI: Scott Simkins
Institution: North Carolina A&T State University
Project Title: Developing an Economics Pedagogic Portal
Project Number: 817382
Type: Phase 2/Type 2 - Expansion
Focus: Creating Learning Materials and Teaching Strategies
Social Sciences Discipline: Economics

Goals & Intended Outcomes: Our economics pedagogic portal (Starting Point: Teaching and Learning Economics) seeks to: (1) introduce economists to innovative teaching strategies developed both within and beyond the discipline of economics; (2) provide instructors with the tools to begin integrating and assessing these teaching strategies in their own classrooms; and (3) promote the sharing of teaching innovations among instructors through a library of instructor-contributed activities.

Methods & Strategies: Partnering with the Science Education Resource Center (SERC) at Carleton College (MN), we developed/revised 16 pedagogic modules through a series of in-residence module development workshops featuring interdisciplinary teams of 4-6 pedagogical experts per module. Each module includes information describing the pedagogical innovation, reasons for its use, directions on how to use the pedagogy, and a library of related discipline-based activities. The Starting Point portal has been introduced to economists through more than 20 regional, national, and international presentations.

Evaluation Methods & Results: In 2010, two external evaluators produced reports on the efficacy of the module development workshops conducted in 2008-2010, in particular the interdisciplinary nature of these workshops. Also in 2010 the evaluators conducted a survey of economists to determine potential interest in Starting Point resources, as well as familiarity with the targeted teaching innovations. The results indicated dissatisfaction with current teaching methods and openness to pedagogical innovation. The full Starting Point site was available to the public in January, 2011. Between September, 2010 and August, 2011 there were 54,024 total visits to the site, 14,285 total unique visits, and 95,529 page views (data compiled using Google Analytics). We continue to monitor site usage and contributions to the module examples/activities libraries.

Dissemination: Since August 2009 we have organized or led over 20 presentations on Starting Point at regional, national, and international conferences. Presentations focus on the overall site or specific pedagogic modules. We have published one article describing the Starting Point portal (Journal of Economic Education; Maier, McGoldrick, and Simkins; 2012) and Starting Point modules are featured in eight book chapters of the International Handbook on Teaching and Learning Economics (McGoldrick and Hoyt; 2011) and 4 other book chapters written by the PIs.

Impact: Through conference presentations and published articles and books chapters, we have been successful in introducing hundreds of economists to new and innovative research-based teaching strategies. We do not know how many economists are using these teaching strategies in their courses but the Starting Point site has maintained high usage since its full introduction in 2011. New recent publications (see above) will further increase interest in Starting Point resources. We are also actively seeking out new contributions to our module examples/activities libraries.

Challenges: An ongoing challenge is attracting instructors to the Starting Point site. In March, 2012 we led a three-day activities development workshop for twenty economics instructors at the Science Education Resource Center (SERC) focused on increasing the number of examples available in the module libraries. Most instructors visit the Starting Point site via a Google search looking for examples to use their courses; in turn, the examples draw visitors to the pedagogic module content. We are actively expanding the number of examples available.

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PI: Roberta Spalter-Roth
Institution: American Sociological Association
Project Title: Innovation in Digital Libraries: An Experimental Examination of the Production, Diffusion, and Use of STEM Teaching Materials
Project Number: 0837121
Type: Phase 1/Type 1 - Exploratory
Focus: Implementing Educational Innovations
Social Sciences Discipline: Sociology

Goals & Intended Outcomes: The primary purpose of this CCLI-funded study is to investigate the changes in the size, density, characteristics, and structure of an affiliation network as a result of the creation of an interactive digital library of teaching and
learning materials (TRAILS). The major study hypothesis was that technology, alone, would not change the characteristics of users and the structure and density of the network, but rather social interventions would be necessary.

**Methods & Strategies:** In order to test the study hypotheses concerning changes in the characteristics of users and the structure of the network, we used unobtrusive measures, from an association database along with addition secondary information to construct a database containing demographic, employment, and disciplinary participation information about the users and the non-users of the paper-based teaching and learning materials prior to and after the implementation of TRAILS. These data were compared using regression and network analysis.

**Evaluation Methods & Results:** Our evaluation method was to use a quasi-experimental design to compare TRAILS adopters to users of ASA’s prior paper-based Teaching Resource Center (TRC) syllabi-sets. The study asks whether the characteristics of the users changed, and how the new technology spread. We found that the demographic characteristics of the teaching and learning materials users remained the same despite changes in technology and that adoption of the new materials occurred through a homophilous network of participants in a scholarship of teaching and learning network and not go beyond this network. The network’s density remained much the same, the network’s core remained small, the users of TRAILS are slightly more embedded within the network than users of TRC materials. Faculty members from non-research institutions continue to dominate the network and its core. Adoption did not follow the traditional pattern of starting slowly and then speeding up, in fact, the reverse was true. We concluded that social interventions would be necessary to diffuse the new technology beyond the current teaching and learning network.

**Dissemination:** The findings from this study were diffused with sociology and beyond to other disciplinary associations. We produced two research briefs and a PowerPoint presentation that are available for downloading for free on the American Sociological Association website. We have conducted a workshop at a REESE and a CCLI PI meeting, as well as several poster sessions. We have presented papers at the ASA national meeting, varied sociology regional meetings, the American Evaluation Association annual meeting and the Sunbelt Network Analysis Conference.

**Impact:** The direct beneficiaries of TRAILS are teachers and the indirect beneficiaries are students. TRAILS contains thousands of teaching resources in more than 70 subject areas (organized by topic, resource type, and pedagogical strategy). For faculty members it reflects a major innovation in the creation and dissemination of peer-reviewed teaching materials including evaluations of how these materials work in the classroom. Users are able to search for and create (through downloading and uploading) specific teaching modules customized to their teaching needs. A personalized web page called My TRAILS displays the newest resources in the subscriber’s areas of substantive and teaching interest. ASA is continuing to expand TRAILS functionality and build its content. Underlying TRAILS is the notion that pedagogy, as well as content, is important for creating good teachers. Thus far nearly 1600 faculty members and graduate students have subscribed to TRAILS, with a grand total of 19,000 downloads in just the first year of the innovative pedagogical materials contained in TRAILS.

**Challenges:** The major challenge we faced was re-establishing project deadlines as a result of the failures to complete the software development on time. As a result, we were one-year late in beginning the project research and evaluation. This meant that we had to request a no-cost extension in order to fulfill the project goals stated in the CCLI proposal.
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