Award Address

Peer-Led Team Learning: 2008 James Flack Norris Award Address

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Why do some students succeed in chemistry and others do not? A common rationalization is to cite individual talent, motivation, and capability. Thus, we provide students the opportunity to listen to our lectures and whether they succeed or not depends on their own dedication, smarts, and perseverance. This model is based in a Horatio Alger mythology of individual success that has its reflection in our stories of individual geniuses of science in the solitary pursuit of knowledge. In practice, however, successful science depends on the interaction of individuals with different skills, ideas, and backgrounds, often working in research teams *(1)*. The social process of developing and negotiating understanding through debate and discussion with peers that is central to science is also central to learning *(2, 3)*. In contrast, the "banking model" of instruction, in which knowledge is deposited in the students' minds by the lecturer *(4)*, is distinctly asocial. While not denying the importance of individual initiative and an appropriate role for the lecture, peer-led team learning (PLTL) recognizes the profound social dimensions of intellectual development and student success *(5)*.

The PLTL model introduces new elements of student leadership and participation by recruiting and training students who were successful in a course to become peer leaders of Workshops for new students. In the weekly meetings, 6–8 students work together to discover solutions to special Workshop problems created by the faculty. The problems focus on ideas that were previously introduced in the text, the lectures, and homework problems. The peer leader facilitates the discussion among the students and plays a mediating role that breaks down the hierarchy between teacher and student. As a result, the students are liberated to become active participants in the development of their individual understanding, guided by assistance from a more advanced peer leader and the benefit of debate and negotiation with their colleagues.

PLTL is an innovative structure that was designed to help students learn chemistry. The model derives from cognitive theories that recognize the power of social interactions *(3)*, distributed intelligence *(6)*, and cognitive apprenticeship *(7)* to facilitate the construction of conceptual understanding. PLTL also works because it is consistent with the social practice of science, the complexity of the human mind, the psychology of human behavior, and our current understanding of the ways people learn *(8)*.

Our Students: An Untapped Resource

In 1991, we began experimenting with peer-led, collaborative-learning groups to improve student success at the City College of New York (CCNY) of the City University of New York (CUNY). This led to a modest National Science Foundation (NSF) curricular grant *(9)* in which we proposed the idea of recruiting undergraduate students who had just finished the course to be facilitators of small-group problem-solving sessions. In contrast to other models of peer-assisted learning, such as tutoring, we conceived the Workshops as an *integral part of the course*, *for all students in the course*. In order to make time for the Workshops, we reduced lecture time by one hour. We found the results to be very exciting: the energy and enthusiasm of the peer-led groups were palpable, *as if a barrier for a highly favorable but kinetically slow reaction had been drastically lowered*. Focus groups revealed the contrast to lectures in which students were reluctant to ask questions; students engaged during the peer-led Workshops because anxiety was reduced, the peer-leaders were approachable, and peers were supportive. Students' comments indicated that the handing down of knowledge in lecture was counterbalanced by egalitarian peer-mentoring and self-reliant growth in the Workshops. Students said: "Leaders know where you are coming from"; "[leaders] are familiar with the way you understand things"; and "I have a chance to express myself and learn from others". In particular, students repeatedly brought up the importance of mistakes on the path to learning: "I have a chance to make a lot of little mistakes". When a fellow student or the peer-leader made a mistake, they were not afraid to challenge and to learn from the resulting discussion. We had discovered an untapped resource for teaching chemistry: the students themselves!

The Faculty Team

Subsequent to these initial efforts in general chemistry at CCNY and other CUNY Colleges, NSF began a new grant program to promote systemic change in chemistry education. Orville Chapman spurred us on by advocating that we "use dynamite, now" on the prevailing models of teaching *(10)*. To develop the peer-led model to its full potential required a diverse team. With the support of a Systemic Change grant *(11)*, PLTL in general chemistry was extended to PLTL in organic chemistry at the University of Rochester (Jack Kampmeier) and PLTL in the general, organic, and biochemistry course (Pratibha Varma-Nelson) at St. Xavier University (Chicago). In both schools, ongoing experimentation with student-led groups had been underway and faculty were inclined to make these an integral part of the chemistry course.

We came to PLTL with different backgrounds and motivations, from different kinds of institutions. David Gosser's interest in student participation in science and learning was stimulated by a presentation by the "Discovery Chemistry" group in 1982 *(12)*. While teaching at The City College of New York, he became interested in problems of student success and motivation, and Joseph Griswold, a colleague in biology, introduced him to Treisman's work with collaborative learning in mathematics *(13)*.

Pratibha Varma-Nelson was educated in India through one year of graduate school. The system included little teaching beyond formal lectures; most of her learning took place through interactions with her peers. Like most of us, she learned in graduate school in the United States about the power of the research group to teach. As a beginning faculty member at St. Xavier University in Chicago she taught as she was taught, albeit with a nagging sense that she was not teaching the way she had learned. As an instructor of mostly female, first-generation students she searched for ways to make students her partners in her teaching and their learning. Some needed to see the behaviors of successful students. The Workshop provided the structure and the peer leaders provided the role models. In parallel to Gosser's experiment, Varma-Nelson replaced part of her lecture time with PLTL Workshops in 1995. Student response, retention, and grades improved!

In 1992, Jack Kampmeier inherited a large second-year organic chemistry course taught in a conventional format of two 75-min lectures and one 75-min graduate student-led recitation per week. Only two-thirds of the students managed at least a C in the course; recitation was not very helpful; and many students did not attend. On reflection, he became convinced that issues of epistemological development were at least as challenging as the subject matter. By 1994, he was ready to meet Gosser and PLTL. In 1995, he collaborated with Vicki Roth, a learning specialist, to select and train peer leaders to introduce PLTL Workshops for some of the class; the Workshop students outscored the recitation (control) group by a wide margin. In 1996, he abolished the recitations and converted the entire course to Workshops.

The three of us worked intensely with each other and a growing partnership of faculty, learning specialists, and students for the next five years to develop the specifics of the peer-led team learning model, defining the necessary training for undergraduates to take the role of leaders, the types of problems and materials best suited for Workshops, and appropriate mechanisms for integrating the Workshops into the course structure and faculty practice. In a snapshot of our early thinking on the PLTL model *(14)*, we explored how PLTL helped overcome barriers to success in chemistry courses by providing a sense of belonging to a scientific community, early and timely mentoring, and diverse approaches to learning.

The Critical Components of Peer-Led Team Learning

1. The Workshop is integral to the course.
2. Course professors are involved in the selection of materials, training and supervision of peer leaders, and they review the progress of Workshops.
3. Peer leaders are selected, trained and supervised to be skilled in group work as facilitators.
4. Workshop materials are appropriately challenging, directly related to tests, and designed for small group work.
5. The Workshops are held once a week for two hours, contain six to eight students per group, in space suitable for small-group activities.
6. PLTL is supported by the department and the institution.

Figure 1. Overview of the six critical components of PLTL.

The Critical Components

As a consequence of our work with Leo Gafney, the project evaluator, a series of critical components for successful implementation of PLTL *(15)* were established, as shown in Figure 1. These critical components allowed us to carefully define PLTL for others and clearly distinguish it from related, yet different, activities, such as one-on-one peer tutoring, study groups, and supplemental instruction *(16)*. In addition, the components provided a useful rubric for us and others to gauge the effectiveness of PLTL implementations *(17)*. This became especially important as PLTL spread beyond the initial core group and was adapted to new situations and disciplines. Each critical component can be elaborated, as a few examples illustrate.

Critical Component 1

"The Workshop is integral to the course" means that the Workshops are an essential feature of the course and not an optional add-on. The Workshop materials and discussions relate logically to and mutually reinforce other parts of the course such as lecture, homework, and exams. Workshops are seen by students as belonging to the course, and as important as lecture, homework assignments, and tests.

Critical Component 3

"The leaders are carefully trained" means that faculty and staff teach effective methods for peer leaders to build productive teams by facilitating student–student discussion, as opposed to leader–student discussion or leader lectures. Emphasis is on knowledge of the discipline as well as on effective teaching and learning techniques for small groups.

Critical Component 4

"Appropriate materials structured for group work" means that problems are appropriately challenging and consistent with the goals of the course. The problems encourage leaders to use collaborative learning tools, such as brainstorming, "round-robin" problem solving, reciprocal questioning, and pair-problem solving. Good materials also include diverse approaches to learning by making use of models, graphical analysis, data interpretation, maps, and metacognitive (postmortem) analysis.

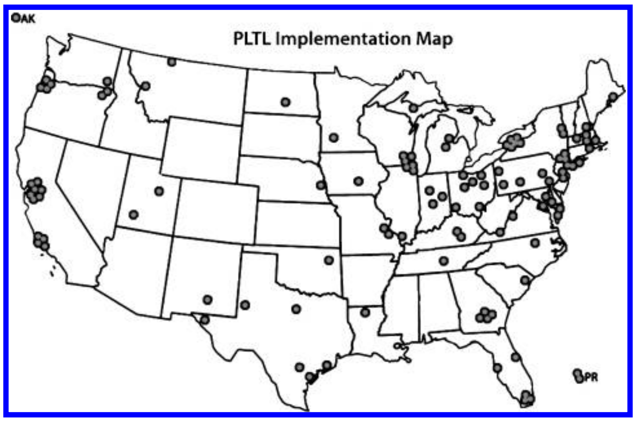

Figure 2. Map showing the general distribution of PLTL implementation sites.

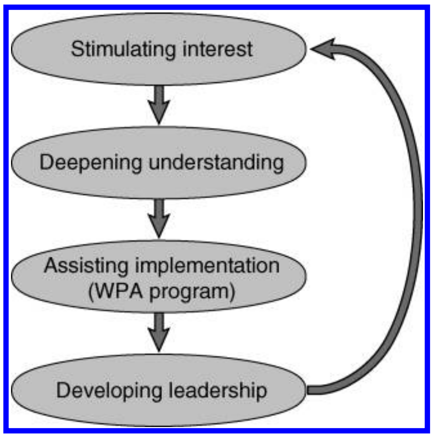

Figure 3. Schematic representation of the PLTL dissemination model.

Critical Component 2

The three critical components above (1, 3, and 4) emphasize the quality and depth of faculty involvement. Critical component 2 elaborates the faculty role itself. The course faculty must meet regularly with the peer-leaders to establish mentoring relationships with and among the leaders, to assist the leaders in developing scientific communities in their Workshops, to analyze and revise the materials of the Workshops, and to build an effective team of faculty, learning specialists, and peer leaders.

Dissemination of PLTL

National dissemination grants allowed us to bring in many new partners to adapt, test, and demonstrate the transportability of PLTL. Summaries of our more fully developed PLTL model were published in two key resources: *Peer-Led Team Learning: A Guidebook (15)* and *Peer-Led Team Learning: Handbook for Team Leaders (18)*. In addition, three workbooks provided models for problems in PLTL Workshops *(19–21)*. These two manuals and the three PLTL chemistry workbooks became valuable resources for the dissemination of the model. The critical components became the framework for a continuing series of faculty development Workshops.

Dissemination was most effective when faculty presenters and peer leaders formed partnerships to present the PLTL model. During the faculty development Workshops peer leaders guided faculty through a problem, with faculty playing the role of the students. Faculty experienced the pedagogy and the power of the peer leader, in real-time practice. The involvement of the peer leaders turned out to be a revelation, as they became convincing spokespersons for the model and essential members of the dissemination and faculty development team.

The dissemination model *(22)* supported implementation and provided leadership opportunities for new faculty to make their own contributions to PLTL, thereby establishing an autocatalytic loop. The Workshop Project Associates (WPA) small grants program *(22)* and a special focus on community colleges *(23)* facilitated nearly 100 implementation experiments; these programs provided many reports on student success, leader training, and institutionalization *(24)*. We ultimately lost count of the number of PLTL implementations, but a conservative estimate is that at least 200 faculty from more than 150 institutions are implementing PLTL, with 2000 trained leaders conducting Workshops for over 20,000 students per year. A PLTL implementation map (Figure 2) gives an approximate picture of the spread of the model, including some implementations beyond chemistry in mathematics, biology, and computer science.

The dissemination model proceeded in a series of steps, as outlined in Figure 3 and described further below.

Stimulating Interest

Presentations at national, regional, and local meetings, a five-volume PLTL series by Prentice Hall, a project news letter, articles in peer-reviewed journals, chapters in books about teaching and learning, and a project Web site (http://www.pltl.org/) were all designed to explain the model and stimulate interest and curiosity.

Developing Understanding

Faculty development Workshops, ranging in duration from three hours to three days, were designed to deepen understanding of the theory and practice in preparation for introducing PLTL. The content was built around the critical components for successful implementation.

Assisting Implementation

The national project offered financial assistance and mentoring for new faculty to implement PLTL Workshops. The WPA program provided up to $5000 per course and a maximum of $10,000 per department; equivalent cost sharing initiated the process of institutionalization. Peer review and mentoring connected the new implementer to the national PLTL network and the support of an external coalition.

Developing Leadership

The national project hosted an annual leadership conference to integrate new adopters and engage them with one another, with project activities, and with planning future directions. The WPA proposals required plans for dissemination of results; new faculty presented at professional meetings and other schools, organized Workshops and symposia, and published papers in peer-reviewed journals to stimulate others' interest and complete the autocatalytic process of PLTL dissemination.

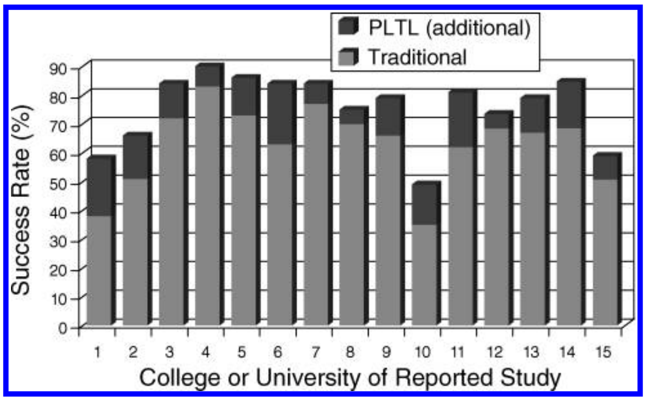

Figure 4. Studies of students' success rates in conventionally taught courses and the improvements observed when the PLTL approach was added to a course's instructional practices.

Student Success

In the early phase of the PLTL project, we chose a simple, uniform measure of student success: %ABC, indicating the percentage of students obtaining grades of A, B, or C as a fraction of the incoming class. While this is not the only possible or most sophisticated measure of student learning, it has the advantage of being widely accepted by both faculty and administrators *(25)*. For instance, our initial results at City College showed an increase in %ABC from 38 to 58% in the first semester of the general chemistry course, when the historical record was compared to PLTL in all sections of the course. Other participants in the PLTL project have reported %ABC, either in comparisons with a historical record or in parallel sections with and without PLTL (Figure 4). The average increase in %ABC across all institutions reporting was 14%, in a diverse group of institutions from community colleges to research universities. Taken together, they point to a positive impact on student success, even though many of these early studies could not control all variables *(26)*.

Following our early reports on student success, several carefully controlled studies on peer-led team learning or close variants of PLTL have been published. At the University of Rochester and Portland State University, the performance of large numbers of students in organic chemistry was tracked and analyzed *(27)*. At the University of Puerto Rico at Cayey (general chemistry), a three- and one-half year study compared groups that chose the Chem-2-Chem program (a peer-led approach) with those who did not *(28)*. At the University of South Florida (general chemistry), one lecture a week was replaced by a PLGI session (peer-led, guided inquiry, a hybrid of peer-led team learning and guided inquiry); PLGI students were compared to those who had the presumed advantage of the additional lecture *(29)*. Washington University in St. Louis (general chemistry) reported a detailed description of their peer-leader training program and compared PLTL groups with non-PLTL groups *(30)*. The University of Maine discussed issues of implementation and attendance in a large-scale program in general chemistry *(31)*. Finally, The University of Texas at Austin (general chemistry) also focused on the training of "pTA" (peer teaching assistants) and compared students participating in peer-led groups with those who did not *(32)*. In each of these independent studies, the evidence indicated significant improvement in students' course performance, comparable to our initial reports. Standardized ACS exams in organic chemistry provided another measure of student success and evidence that content was not compromised by introducing the peer-led Workshop *(33)*.

Effects of PLTL on Peer Leaders

Peer leaders are at the center of PLTL. From the earliest days of the project it was evident that serving as a peer leader was transformative. The peer leaders form a bridge between faculty and students, helping the students understand and respond to the expectations and goals of the faculty. In turn, faculty members learn about the needs and concerns of the students from the leaders. As a result, the peer leaders' relationship to the course and the faculty is dramatically changed from student to partner. To be effective in their new roles, peer leaders must develop new communication skills, effective team-building tactics, an understanding of the ways people learn, a more nuanced understanding of the course content, and a variety of methods to help students learn that content and the associated problem-solving skills.

A survey of former peer leaders revealed their view that participating in Workshops and acting as a peer leader were among their most productive college learning experiences *(34)*. Peer leaders reported increased confidence in entering science-related careers, increased interest in teaching, and greater effectiveness in their interactions with people in a wide range of situations *(34−36)*. A related study *(36)* documented and categorized peer leader gains as cognitive, personal, and instrumental, the latter referring to résumé building and preparation for the MCAT exam. The following quotes *(34)* are illustrative.

> "It was the first time I realized how many gaps there are in my own understanding of chemistry.""The questions of others helped me see different viewpoints and perspectives.""I gained the knowledge and confidence I needed to pursue a career in pharmacy. In pharmacy school I became known as the group leader."

In a different kind of study *(37)*, students who served as peer leaders in an introductory (prep) chemistry course outperformed all others in grades and completion in the first-semester general chemistry course and in the number of subsequent chemistry courses taken.

Faculty and Their Institutions

PLTL was driven forward by instructors searching for ways to improve their courses. As it developed, it also became a student-driven program that received significant impetus and legitimacy from the enthusiastic responses of students and peer leaders. Although PLTL requires that students and faculty rethink their roles and responsibilities, there is also a conservative element that facilitates change. Students still use a textbook, attend lectures, are expected to do preparatory homework, and are rewarded for their individual accomplishments. Faculty members continue to be in charge of the goals and standards of their courses; they continue to lecture, albeit often in revised form; they still write and grade exams. On the other hand, PLTL asks faculty to recognize the limitations of the lecture−recitation model of education and acknowledge that student success is more directly related to student motivation and engagement than to the quality of the faculty presentation. PLTL also requires faculty to choose and train peer leaders, negotiate for funds to pay the leaders, prepare appropriate materials, and find suitable time and space for Workshops. Much of the dissemination work of the PLTL project team was designed to reduce the barriers to implementation by providing models for Workshop problems, leader training, and partnerships among faculty and learning specialists and peer leaders.

There are many positive returns for faculty who implement PLTL. Foremost is improved student achievement and attitude about the subject and the course. In practice, many faculty find that preparing materials, learning a new research literature, designing and implementing peer leader training, and evaluating the impact of their PLTL initiative offer new opportunities for creative scholarship and teaching. The peer leaders are among the best students in the institution and faculty find it challenging and satisfying to work with them in new dimensions of their education. Many also find rewards in collaborating with like-minded colleagues in the PLTL network and in mentoring new participants.

Institutions have also been challenged by PLTL to rethink their roles and responsibilities. In the most general sense, PLTL represents a transition from faculty-centered to student-centered teaching, with implications for a broad range of institutional structures and practices. For example, PowerPoint presentations and the traditional lecture hall are physical expressions of faculty-centered instruction. PLTL needs new spaces, designed to optimize student–student interaction. PLTL also challenges the institution to design faculty evaluations that are focused less on lecture performance and more on outcomes, and to recognize that constructing effective Workshops *is* teaching. PLTL also requires a financial commitment to compensate the peer leaders or provide some form of appropriate recognition of their contributions.

Many institutions have recognized that PLTL is a good fit to their priorities, such as improving retention and developing student leadership; they have found inventive ways to respond to the needs of the program. In general, it is important to demonstrate local success and positive student response, and effectively relate these to institutional missions. Partnerships of faculty, staff, and students are especially powerful because the administration hears a common message from different constituencies. Some colleges and universities have made PLTL a priority, with the result that a faculty-up program receives top-down support to expand to other courses.

There have been some attempts to disseminate PLTL beyond its country of origin. Notably, Varma-Nelson has presented in China and India, where students learned about the PLTL model along with the faculty members. While the teachers we met had reservations about the changing role of students, the students expressed enthusiasm for leading PLTL efforts while also mentioning dissatisfaction with current, more top-down approaches to teaching. We look forward to continued dialogue and to exploring how PLTL can be adapted to different countries and cultures.

Lessons Learned

Insights from the PLTL project are transferable to other projects. The seven summarized below are perhaps the most notable.

•Peer leaders are invaluable allies for educational change; they have a unique credibility with other students, faculty, staff, and administrators. As recent learners of the material, they have unique insights about the subject, the course, the challenges, and the proposed changes.

•The critical components and the dissemination model provide generalizable templates for implementation, evaluation, and propagation of educational change.

•Lecture can be reduced without compromising content if the time is spent on activities that promote active engagement of the students with the subject matter and with each other.

•When students are asked to learn in new ways, they need to know the reasons for change and have opportunities to learn their new roles and responsibilities.

•Answer keys short circuit discussion and promote the notion that only one way exists to solve a problem. Using answer keys discourages the process of learning to solve problems and evaluate and defend answers.

•PLTL is flexible and does not require strict adherence to a specific theoretical structure; it can be usefully informed by new ideas about Workshop materials and peer-leader training. "Adapting and adopting" invites new faculty and institutions to take ownership of the pedagogy, although limits to adaptability exist, as indicated by the critical components *(17)*.

•A vibrant network of allies, both internal and external, from different backgrounds and experiences, is an essential element of dissemination and provides insight into tactics for curricular and institutional change. Faculty can partner with peer leaders, teaching assistants, learning specialists, and centers for teaching and learning to find the necessary resources for change. These partnerships are two-way streets that help both parties do their jobs more effectively and create opportunities for new initiatives and collaborations.

Next Steps for PLTL

Overviews of PLTL in organic chemistry *(33)* and general chemistry *(38)* have appeared, and the fifteen-year record of the PLTL project was comprehensively documented and evaluated in a recent monograph *(17)*. Nevertheless, there is much more to understand about the pedagogy and the processes of sustainable change and institutionalization *(39)*. We continue to view PLTL as an active area of research, open to contributions from all participants. While the impact of PLTL on grades, student response, and leadership development has been documented, opportunities exist for more probing studies on the development of thinking skills *(40)*. Detailed descriptions of leader-training programs have been reported *(41, 42)*, but there is room for new ideas and, especially, for analysis and evaluations of the effectiveness of current practices. We need more information about the behavior of the peer leaders and the relationships of their behavior to student achievement. A study, "Discourse in PLTL", is in progress *(43)*. PLTL shares common ground and opportunities for stimulating exchange with problem-based learning (PBL) and process-oriented, guided-inquiry learning (POGIL) *(44)*. Peer-led guided inquiry (PLGI) is a notable example of the marriage of PLTL and POGIL *(29)*.

Much of the creative work in PLTL revolves around designing methods and materials for Workshops in chemistry and other disciplines and for peer-leader training. Workshop materials for mathematics, biology, and anatomy and physiology are now available *(45)*. An experimental "small footprint" textbook that integrates readings with PLTL Workshops is the focus of a PLTL conference *(46)*. Although PLTL was conceived in connection with the lecture course, substantial opportunities exist for new applications in laboratory courses. Work has been done to introduce student-led laboratories *(47, 48)* and the CASPiE (*49*) incorporates PLTL into their work to introduce research in undergraduate laboratory courses. PLTL seems especially well matched to guided inquiry experiments *(50)*.

A quick examination of abstracts of grants awarded in CCLI, S-STEM, STEP, ATE, and Noyce Scholarship programs at the Division of Undergraduate Education at NSF reveals that the PLTL model is being used in a variety of ways in STEM disciplines to improve retention in gateway courses, to recruit students from underrepresented groups into STEM fields, to improve graduation rates, to design bridge programs, and to prepare future teachers.

Conclusions

Students are at the heart of the PLTL structure. In undertaking this project, we established new partnerships with our students and our peer leaders; we learned to rely on the intelligence, the energy, the desire to learn and to help others learn, and the remarkable tolerance and generosity of our students toward one another. The peer-led Workshop results in an improved learning environment and increased student success because the peer-leader role and the structure of the Workshop mobilize the power of student−student interactions to facilitate learning.

We are excited and optimistic about the future of PLTL. In the PLTL project we have worked with thousands of peer leaders, many of whom are now in graduate and professional schools and in the first stages of their professional lives. They have internalized PLTL and are now making it a continuing component of their education and the education of others. If it is true that we teach as we were taught, then there are also many thousands of students who learned in at least one PLTL Workshop; some will teach and use learner-centered pedagogies to get new students to say “yes, we can” learn chemistry!

Acknowledgment

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