Cafeteria-Style Grading in General Chemistry

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One need only scan the pages of any issue of this *Journal* or speak with a textbook representative to realize that the resources for teaching and learning general chemistry are designed to meet a wide variety of learning styles, technological resources, and personal preferences. Both students and instructors are now inundated with a wealth of supplementary materials such as CDs with chemical animations, homework, and quizzes; access to sophisticated online interactive tutorials; and well-designed cooperative and collaborative learning experiences. The continually expanding variety of materials is attractive, but for any one course only a few of these materials could possibly be required owing to time restrictions and logistics. Usually the instructor chooses required components for the entire class according to his or her own personal preferences, perceptions of their effectiveness for students, cost, and technical resources available to students, without direct involvement of students in these decisions.

To take better advantage of this variety we devised "cafeteria-style" grading (CSG). This simple method allows students to choose course components and specify how much their performance in these components will count toward their final course grade. Our implementation of this approach began in the summer of 1999 as a result of our students' expressed frustration with their required participation in certain course components. These included peer-led team learning (PLTL), specifically in the Workshop Chemistry program (WSC)[1] (*1*); computer-aided instruction (CAI) using graded ChemSkill Builder (CSB) assignments (*2*); and a routine of in-class active learning activities and individual quizzes. To put the development in perspective and provide a basis for evaluating outcomes and learning, we turn to the year we began teaching at CCU.

In 1996 the general chemistry sequence at CCU had a traditional lecture-only format, with laboratory and recitation required as part of the overall 4-credit-hour course. Written homework sets from the textbook were assigned and graded for a small percentage of the course grade. The outcomes of the course in terms of student attrition and grades were bleak. Only 55% of the students who took the first exam received an A, B, or C for the course, even though the course grades were inflated by about 10% by including the generally high laboratory grades as 25% of the final grade. Without the laboratory component the proportion of A's, B's, and C's dropped to 29%.

This poor level of performance led us to seek new course components that were introduced in the General Chemistry Teaching Workshop held at SUNY–Stony Brook in July 1997. We gradually added computer-assisted instruction, in-class group work, and Workshop Chemistry to the required and graded components of the course during the following two years, setting their weights as only very small percentages of the final course grade. We found that the number of students receiving A's, B's, and C's gradually increased from the original 55% to a consistent level of about 75–85%.

However, along with this improvement in student success, signs of student frustration appeared. Some students did not participate effectively in WSC or CAI. Some of the students in workshops openly expressed their frustration and even hostility, making the workshops unpleasant for all participants and detracting from the program. Many of our students are non-residential, nontraditional students with work and family responsibilities, so that meeting outside of class time might be considered a waste of time. For instance, our WSC program has 90-minute sessions of peer-led study groups that meet outside of lecture and laboratory times once each week. The CSB homework sets can be done on a home computer and submitted for credit, and generally take students several hours each week. Both WSC and CSB were strongly embraced by different groups within the class, but neither component was used by all students.

In introducing CSG in summer 1999 in response to these difficulties, we were concerned that students would not understand their own learning preferences well enough to choose course components easily and effectively, but CSG met with strong student approval from the beginning. Since it allows credit for the course components that the students intuitively find most suitable to their self-determined needs, students felt that their learning would be reflected in their course grades. The extra motivation of a direct grade reward for effective study encourages greater participation in the course overall. The general approach is a simple, widely adaptable method for providing students choice among any set of graded course components. The use of spreadsheets like Microsoft Excel makes the individual selection of grade-weighting percentages practical for grade management even for relatively large classes. We have maintained individual grade-weighting schemes for classes of 80–150 for the last two semesters.

Implementation and Assessment of Cafeteria-Style Grading

We gave students a grace period of several weeks at the beginning of the term, with ample exposure to all the course components, before they committed to their personal grade-weighting schemes through a signed contract. For first-semester students, organized workshop sessions involving the peer workshop leaders were offered as an example of the WSC method before actual workshops were organized and rosters determined. Explicit links were made between the textbook and workshop materials to encourage students to try out real workshop meetings before committing to them for grades. The CSB program was demonstrated in class and its role in the overall pedagogical method was discussed so that students could gain experience with the program before using the software. In-class quizzes, group learning activities, and one written exam were given before students were required to submit their CSG contracts. Explanation of the particular emphases of different course components and how each fit into the entire learning process was provided. Issues of student preferences, logistics, and learning styles were also discussed in class.

Because many first-semester students seemed bewildered by the concept and by the mathematics involved in a grade-weighting scheme, explicit examples of grade calculations were provided. We set a default scheme that could be changed only by submitting a signed contract with percentages within prescribed ranges by a specified date soon after the first exam. An example of the default percentages and ranges is shown in Table 1. These have varied a bit according to the instructor's preferences.

Once the date for submission of the contract had passed, the percentages desired by each student were entered into the Excel spreadsheet for calculation of final course grades. A sample of an Excel spreadsheet is shown in Figure 1.

Learning in the course was evaluated by comparing scores on two exams: the ACS Division of Chemical Education Toledo Placement Examination given during orientation and the first day of class, and a CCU department-standard final exam for the first-semester course. Both courses covered the same material and used the same final exam. The ratio of these scores, defined as r = (normalized final exam score)/(Toledo test score), was used as a measure of *improvement* in the course to minimize the effects of the wide range of preparation for the course. As a final assessment of the success of CSG for student retention and course grades the percentage of students receiving A's, B's and C's is also given.

Table 1. An Example of a CSG Scheme for General Chemistry I

Component	Default (%)	Allowed Range (%)
Lecture/class participation—all quizzes	10	10–20
Regular exams	50	30–65
Final exam—comprehensive	20	15–35
Computer homework	10	0–20
Workshops	10	0–20

Student Response to Cafeteria-Style Grading

The students' selection of the two optional course components in the first three offerings of CSG shows a desirable trend toward selecting more components that involve ongoing active participation in the course. The relatively large fraction of students who chose to participate in Workshop Chemistry for a grade increased from 50% to 88% during the three terms studied, and CSB participation remained high (90–95%) throughout. One factor in this choice may be that a marine chemistry course required for the popular marine science major awards extra credit for General Chemistry review by use of the CSB software. It is notable that participation in both CSB and WSC in second-semester General Chemistry in spring 2000 was sharply higher than the first-semester participation for the same cohort (88% vs 60%).

A survey of student participation in the various course components, the relative value of the chosen components, and the students' assessment of the approach was taken in the final week of class. The results are summarized in Figure 2. Note particularly the overall response to statement 3, and the breakdown of responses by course component(s) chosen (items 4 and 5). Whereas only 40% of the students who chose only CSB in summer 1999 agreed with the statement "The course components I chose matched the coverage of the course", 83% of those who participated in both CSB and WSC agreed with the statement. There was a significant decrease in the positive responses in fall 1999, when only 33% of the CSB group and 57% of the CSB-plus-WSC group agreed with the statement. Other factors such as class size, number of instructors using the approach, and the pace of the course may be important in understanding these differences. The summer course involved only 19 students in a class taught by one of us (JAG), whereas

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Averages of Course Components						Weighting %						
2	**Name**	**Quiz**	**Exam**	**CAI**	**Workshop**	**Final Exam**		**Quiz**	**Exam**	**CAI**	**Workshop**	**Final Exam**	**%sum_test**	**Course average**
3														
4	test	100	100	100	100	100		10	50	20	10	10	100	100
5	student 1	84	65	95	95	68		20	30	20	20	10	100	81.1
6	student 2	64	78	75	68	75		10	60	5	5	20	100	75.35
7														
8	The weighted course average is determined by the formula:													
9	N4=(H4*B4+I4*C4+J4*D4+K4*E4+L4*F4)/100													
10														
11	A test sum is used to avoid data entry errors:													
12	M4=SUM(H4:L4)													

Figure 1. A sample spreadsheet for calculating student course averages with the CSG scheme.

CSG/Course Components Survey Statements

1. The grade-weighting scheme allowed me to get the best grade I could.
2. The grade-weighting scheme allowed me to learn chemistry in an efficient manner.
3. The course components I chose matched the coverage of the course exams.
4. *Statement 3: responses for group that used CSB only.*
5. *Statement 3: responses for group that used both CSB and WSC.*
6. The limits of allowed points for various course components were fair.
7. The different components of the course that were offered fit my needs.
8. It was easy for me to decide which components to use.
9. I would like to have the option of my own grade-weighting scheme and various course components in other courses.

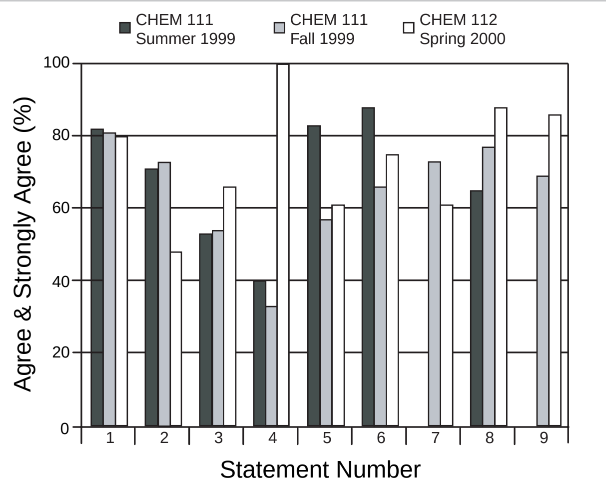

Figure 2. Responses to CSG survey. The response choices were *strongly disagree*, *disagree*, *neutral*, *agree*, and *strongly agree*. Statements 7 and 9 were not presented to the section taught in summer 1999.

the fall term included 136 students taught by both of us in two separate sections.

The following are some comments about the grade-weighting scheme that were not covered by the survey.

> I think it's a great way to motivate students to study via CSB and Workshop.

> By allowing us to count [them], there is more incentive to take the time to actually do CSB and Workshop.

> [CSG] was a good idea, but it was limited and didn't fully cover [possible] options. People who work better with their hands on projects [should have a choice of a component suitable to a kinesthetic learning style].

Student performance levels were also assessed according to the choice of course components. We measured individual student improvement by calculating the ratio of the normalized first-semester final exam score to the Toledo Test total score. Each test was based on a total of 60 points in the normalization. From the average of these "improvement ratios", shown in Table 2, it is clear that students who chose both CSB and WSC components found better support for their performance on exams than those who chose only CSB in the five-week summer course. This effect was not observed in the fall. Only in the fall were there students who did not make use of either CSB or WSC. Their lower average performance is evident in their normalized improvement ratio of 0.67, compared to 0.98 and 0.93 for the other categories.

Table 2. Average Grade Improvement Ratio and Success Rate in General Chemistry I

Class	Grade Improvement Ratio			A-B-C (%)
	CSB only	CSB and WSC	Neither	
Spring 1999	—	0.86[a]	—[a]	72[b]
Summer 1999	0.87	1.12	—[c]	83[b]
Fall 1999[d]	0.98	0.93	0.67	61[e]
Spring 2000[f]	no data	no data	no data	77[e]

[a]Both components, CSB and WSC, were required.
[b]These were lecture-only grades even though the final course grade included the laboratory component until fall 1999.
[c]There were no students in this category.
[d]All sections were taught by JAG. During this term CSG was also introduced in a section of 25 students in General Chemistry II.
[e]The cohort of students who took General Chemistry II in spring 2000 adapted better to the CSG scheme; their A-B-C rate was 82%.
[f]These sections were taught by a temporary instructor using the same materials as JAG.

The trend in student selection of course components is also evident over the three-semester period. Although all students chose CSB as a graded course component in the first offering of CSG, only 47% chose both CSB and WSC. In the fall semester, 92% opted for CSB and 71% chose a combination of CSB and WSC. The effect of student experience and course reputation may be evident in the percentages in spring 2000, when 94% chose CSB and 82% chose the combination. By contrast, when these course components were compulsory but had lower grade weights, actual participation and performance were much lower and student acceptance was much worse. For example, when CSB was required and counted at a fixed rate of 10% of the course grade, the success rate in the course was 72%. When it was optional and could count for as much as 20% of the course grade, participation was close to 100% and the success rate was 83%.

In our early implementation of WSC it was a required part of the laboratory course, which counted as 20% of the overall chemistry lecture and laboratory. The fixed contribution of the WSC component to the overall course grade was 2.5%. We have since made the laboratory a separate one-credit course, so that laboratory and lecture grades are not averaged together. In the current CSG scheme for the lecture course, a much more involved evaluation process is used for Workshop Chemistry, but students may count that component as much as 20% of their lecture class grade. We have devised a grading scheme for workshops based upon participation, and an evaluation of group problem-solving for this purpose.

Discussion

Evaluating their own learning processes and gauging their performance level in particular components is a challenge for many students at this level. Some, lacking the intellectual maturity for this, may not rise to the challenge of taking responsibility for their own learning, but respond to the reputation of the course and take what they perceive as the path of least resistance toward success.

While the connection between learning improvements and active participation in course components is difficult to measure, the comparison of the improvement ratios, *r*, in Table 2 show some trends for very similar courses. In the spring semester of 1999, the General Chemistry I course required students to participate in CSB, WSC, and in-class group activities very similar to those later used in the CSG components. In that course, the average *r* was 0.86 with a standard deviation of 0.19. In fall 1999, when there was choice among these several components, the overall average was 0.95 with a standard deviation of 0.20. So even though the A-B-C% was actually lower in fall 1999, the students' improvement was measured to be 10% *better.* The adaptation to the change in the course grading was quicker in the second-semester course in fall 1999 and improved in all the spring 2000 courses.

The range of allowable percentages in the CSG will require judgment on the part of the instructor to encourage a balance of task-oriented student learning (*3*) and more traditional evaluative activities. The task-oriented activities in our project were CSB, traditional written homework, WSC, and group activities in class. Our traditional evaluation components were written tests, quizzes, and a final comprehensive standardized exam. The CSG scheme could easily be adapted to other types of grading components such as portfolios, writing assignments, or construction of Web pages. We offer this particular combination of course components only as our current example of the use of CSG. Indeed, our success has encouraged us to integrate more traditional and nontraditional course components in our general chemistry courses in the future.

Note

1. Coastal Carolina University is one of seven institutions in the Workshop Chemistry Consortium of 1998 (WCC98) that were awarded an NSF-CCLI-AA grant in September 1998 (NSF DUE 9950575) to adapt and adopt the Workshop Chemistry program. These seven institutions are Miami University, Goucher College, SUNY Environmental Science and Forestry, Prince Charles' Community College, State University of Southwest Georgia, Indiana University–Purdue University at Indianapolis, and Coastal Carolina University.

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