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Overcoming Student Resistance to a Teaching Innovation

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Keywords
Calibrated peer review, Educational tools

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Introduction

The transformation of college courses from teacher-centered to learner-centered often involves the introduction of new methods of learning or assessment in which students play an active, responsible role. Research suggests that students who have come to expect a more passive role in their formal education may initially resist such new methods (e.g., Smith, Cooper, & Lancaster, 2002; Van Patten, 2000; Vuorela & Nummenmaa, 2004). As Boud (1981) pointed out, "Student reticence and resistance to taking responsibility for learning are likely to be among the first problems the teacher will meet" (p. 13). Often technology-based innovative tools are implemented to enable more self-directed learning. Diffusion theories focusing on the manner in which an innovation is accepted and adopted by a group have been used to increase the adoption of various technologies in education (Surry & Farquhar, 1997). One of the most widely-used diffusion theories is the Theory of Perceived Attributes (Rogers, 2005) stating that an innovation has five attributes which form the basis of judgment by the receiving group: (a) trialability (can be tried before implementation); (b) observability (presents observable results); (c) relative advantage (is relative to what is being used); (d) complexity (is not too complex); and (e) compatibility (is compatible with practices and values). Researchers suggest that student attitudes and expectations, which are related to practices and values, impact performance (e.g., Cheung & Huang, 2005; Cuban, 1993). Students may resist innovative tools that prompt self-

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directed learning since it requires a shift in student thinking about responsibilities of learners and teachers (Akerlind & Trevitt, 1999). In addition to this, innovation—especially when it is being imposed externally—may produce anxiety and disorientation (Akerlind & Trevitt, 1999). Many experienced faculty, like other professionals, deal with problems like this intuitively by reflecting on these student issues and changing teaching strategies to meet their students' needs. This activity is described as reflection-in-action, which is the process that allows one to restructure a project while working on it. The process is more than "trial-and-error;" it is a collection of purposeful decisions that are made by a professional after being surprised by an unexpected turn-of-events in the midst of the project. The astonishment causes one to rethink and question an original premise. When an original model of thought does not work, upon reflection one then arrives at new ways to address the issue (Schön, 1983).

This paper presents a study exploring student response to a particular technological innovation—Calibrated Peer Review (CPR)™—in an introductory chemistry class. Our research team and coauthors of this paper consisted of the instructor of the course and two faculty developers, who had been involved with helping science and mathematics faculty design and implement CPR assignments. The instructor had used CPR for seven semesters and had surveyed student perceptions at the end of each semester. She came to the faculty developers with the survey results; while she had used student feedback informally to improve her implementation, she was now interested in doing more in-depth analysis of the data. Together, we approached the data with two research questions: (1) What do students think about CPR as a learning tool? (2) What do student comments reveal about the reasons for their acceptance of or resistance to CPR? The data included both quantitative information from Likert-scale items and qualitative information from an open-ended question. As we read comments from the early semesters of implementation, the faculty developers on the research team were struck by fact that the instructor had persevered despite the early vehemence of students' resistance. This gave rise to a third research question: (3) Why and how did the instructor persist? We believed that insights gained from this analysis would enable us to help other faculty in their implementation of teaching innovations. To investigate this question, we interrupted our analysis of student comments on several occasions so that the faculty developers could confer with the instructor on how she introduced CPR to the students, how she modified her approach, and why she persisted even though students resisted. The instructor's reflections enriched our combined understanding of what had occurred while the student comments prompted probing questions and deeper reflection. While the inquiry and analysis process was spiral-like rather than linear, in this retrospective description we attempt to communicate the methods and results in a linear fashion.

We begin with an explanation of CPR, which is followed by the study's methods, including the instructor's description of the changes she made in class throughout the semesters (in her own voice). Next, we discuss the findings of the quantitative and qualitative data, which include the faculty member's reflections on her instructional modifications that resulted in greater student acceptance of this innovation.

Calibrated Peer Review™

Calibrated Peer Review (CPR)™ is a web-based program that facilitates the use of writing as a learning and assessment tool. Initially developed at UCLA for the Molecular Science Project (http://cpr.molsci.ucla.edu/), one of the NSF-supported Chemistry Systematic Reform Initiatives, CPR has been used in a wide range of disciplines. After instructors create

assignments using the authoring tools, students complete the assignments through three phases: (1) Following the instructions, they access suggested resources, and write and submit their essays; (2) they practice reviewing by grading three sample essays, created by the instructor, which exemplify a low-quality, medium-quality, and high-quality essay

(called calibration essays); and (3) they grade the essays by using "calibration questions" (the rubric) also created by the instructor. The CPR software assigns a reviewer competency score based on a comparison of the student review to the instructor review of each essay. Students then review three classmates' essays (randomly assigned and anonymous) and their own essays, using the same calibration questions.

Instructor-reported experiences and a limited number of studies have suggested that CPR is a tool that can help students master content, improve writing skills, and become more competent reviewers (Furman & Robinson, 2003; Margerum et al., 2007; McCarty, Parkes, Anderson, Mines, Skipper, & Greboksy, 2005; Pelaez, 2002; Russell, 2001). Gerdeman, Russell, and Worden (2007) examined the development of 1330 students' writing and reviewing skills in an introductory biology course and found that students showed improvement in writing and reviewing over three CPR assignments. The design of CPR was motivated by a belief that writing and peer review can help students learn content and critical thinking skills. Research by educational researchers and practitioners has demonstrated that having students write (e.g., Barnett & Blumner, 1999; Herrington, 1997; Klein, 1999; Lowman, 1996; Paul, 1995; Rivard, Stanley, & Straw, 2000; Sternberg, 1994; Wright, Herteis, & Abernethy, 2001) and review each other's work (e.g., Boud, 1990; Cutler & Price, 1995; Dochy, Segers, & Sluijman, 1999; Orsmond, Merry, & Callaghan, 2004; Pope, 2005; Reese-Durham, 2005; Sobral, 1997; Topping, 1998) are effective ways of teaching and learning. It should be noted our aim with this study is not to investigate the usefulness of CPR, but to find out student reactions as well as the steps taken to overcome student resistance to an innovative technological tool.

Background Information

The focus of the study is a first-year general chemistry class which is a two-semester sequence involving almost 3000 students each semester at Texas A&M University (TAMU). Students attend three hours of lecture per week in a class of 250-300 students and participate in a weekly three-hour lab in sections of 24 students, taught by graduate teaching assistants.

In Spring 2002, CPR was introduced to faculty teaching in the First Year Chemistry Program during an NSF-sponsored Multi-Initiative Dissemination workshop. The instructor had always included writing in her large chemistry classes, but saw CPR as a way to increase the amount of writing without additional graders. She convinced the program's director that CPR was worth trying and the decision was made to implement CPR in all sections of general chemistry beginning in Fall 2002. This study involves only the students in her sections. At the end of each semester of implementation, she collected student feedback with Student Assessment of Learning Gains (SALG, http://www.wcer.wisc.edu/salgains/instructor/), a customizable web-based program designed to capture student perceptions of their learning gains during a given course.

Methods

The specific research questions addressed in this study are:

(1) What do students think about CPR as a learning tool?

(2) What do student comments reveal about the reasons for their acceptance of or resistance to CPR?

(3) Why and how did the instructor persist?

While quantitative data from the online survey, SALG, were used to investigate the first research question, qualitative data (student comments) from the survey were used to investigate the second research question. During the analysis of student comments, the third research question, focusing on the instructor's experience, arose. The instructor in our study (and the first author of this paper) was initially motivated to use CPR because she believed that writing could help her chemistry students learn essential course content and that peer review could help develop their critical thinking skills. The resistance she encountered, while understood in retrospect, was unexpected. Despite student angst and even antagonism about CPR, the instructor persisted and we (the faculty developers) wanted to know why. In addition, the nature of the student comments gradually changed and we wanted to know if there were modifications the instructor made that could account for this change. To address these questions, we asked the instructor to reflect and write about her implementation of CPR. Her reflections and answers to the third research question are presented in the findings section.

Participants in the study were the 1515 students in the instructor's sections of first-year general chemistry during seven semesters (Fall 2002 - Spring 2006, excluding Fall 2003). Students were asked to complete the SALG survey several days before their final exam; completion was worth 5 points on their final. Students logged into the web-based program SALG with their names so credit could be given, but SALG dissociated their names from their responses, maintaining anonymity while motivating students to complete the assessment. The response rate ranged from 94-98% over the seven semesters.

Research Question 1: Quantitative Analysis

In order to investigate what students thought of CPR as a learning tool, we conducted a quantitative analysis of the five SALG survey items pertaining specifically to CPR:

1. Do you think that future classes should do CPR? Please explain.
2. I enjoyed doing the CPR assignments.
3. The CPR assignments helped me learn some chemistry.
4. The CPR assignments helped me improve my writing skills.
5. The CPR assignments helped me learn to critique my own writing and that of others.

While students answered item 1 with a yes/no response with further explanation, they rated items 2-5 on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Quantitative analysis included: (1) the tabulation of responses to items 1-5, (2) correlational analysis among responses to items 2-5, (3) analysis of the relationship of

items 2-5 to item 1, and (4) chi-square analysis on pairs of items 2-5 for each semester.

We also wanted to investigate whether students' suggestions that future classes use CPR (positive responses to item 1) necessarily reflected a positive experience with CPR, which would be summarized in their responses to items 2-5. Thus, we averaged the responses to items 2-5 for each student and interpreted an average of less than 3 to be an overall negative experience and greater than 3 to be a positive experience. Then, we calculated the percentage of students in each semester that fell into the following four groups:

Group 1: Students who had a negative experience, yet wanted future classes to do CPR.

Group 2: Students who had a negative experience and did not want future classes to do CPR.

Group 3: Students who had a positive experience and wanted future classes to do CPR.

Group 4: Students who had a positive experience, yet did not want future classes to do CPR.

Finally, for each group we counted the number of positive and negative statements obtained in the qualitative analysis to observe if the quantitative determination of their positive or negative CPR experience was linked to either their qualitative responses or their wish to have future classes do CPR.

Research Question 2: Qualitative Analysis

Qualitative responses ranged from phrases to paragraphs written as responses to item 1, "Do you think future classes should use CPR?" From the 1515 students, 1264 provided explanations to this question; 37 explanations were ambiguous, such as "I don't care," and were not included in the analysis. Using qualitative methods of analysis, we looked for patterns and themes in these explanations that investigated the reasons for student acceptance of or resistance to CPR. We read through all responses from one semester and came to consensus about what categories we would use and how each statement would be coded. The categories that emerged reflected our desire to understand why students liked or did not like CPR and in what ways they perceived it to affect their learning. The participation of the instructor in the coding process was critical because she was able to provide contextual information that helped us to understand the student comments. After coding each semester's data we refined our categories, adding new ones where needed and combining others. After coding the entire data set, we tabulated the results.

Research Question 3: Semester By Semester Implementation

Below is the instructor's description (in her own voice) of how the implementation of CPR in her first-year chemistry class evolved. While this section contains minimal explanation, a detailed reflection of how and why she modified implementation strategies are presented in the findings.

Fall 2002

Initially, I recognized that I could not ask students to do CPR in addition to all of the work I had traditionally expected. To allow time for CPR, I decreased the number of labs per semester from ten to seven. My students completed four CPR assignments with only the best three scores counting toward their course grade so no makeup assignments had to be given. Each CPR assignment was equivalent to a lab report, making CPR worth 5% of the

total grade. Since CPR was originally a chemical education tool, there were many assignments already available for use. Thus I took all CPR assignments from the CPR library rather than designing assignments specifically for my students. I gave the students a short two-page handout explaining CPR.

Spring 2003
I implemented CPR in the same way as Fall 2002 in terms of the number and weight of assignments. After glancing at student feedback, I wrote a detailed four-page handout that included sections on how to do well on CPR and how to interpret their CPR scores. I reframed CPR in my discussions with the students as an alternative way of assessing their

chemistry capabilities; as something that could help, for example, those students who do not do well on multiple-choice tests. Finally, I emphasized my availability to help all students with technical elements of the CPR software.

Fall 2003
Family Educational Rights and Privacy Act (FERPA) issues led my department to decide that all student data (identification numbers and grades) needed to be kept secure on a server inside the Texas A&M firewall. Because UCLA and Texas A&M had a joint NSF grant involving CPR, the university was able to put CPR on its own server and I became the university's CPR administrator because of my experience with the program. In Fall 2003, my class did only one assignment to test the new system and I did not ask them to provide feedback; thus, this semester is not included in our study.

Spring 2004
Students completed three CPR assignments, with only the best two assignments counting toward their grade, since I could only replace 2 labs that semester. The CPR assignments were worth 3% of the total grade. Two important changes in implementation occurred during this semester. First, instead of using only assignments available in the CPR library, I wrote two of the assignments, "Plagiarism in TAMU Laboratories" and "Measurement & Significant Figures." Second, I stated clearly that, when asked, I would be happy to look carefully at peer-ratings and adjust scores if warranted.

Fall 2004
Changes made for this semester were in support of my attempt to meet the university guidelines of a "W" course and included both adjustments to grading policies and changes in presentation of CPR to students. I told my students that my class was writing-intensive on the first day and included this fact in my syllabus. My students returned to doing three fewer laboratories than students in other sections. To emphasize this, in the syllabus' laboratory calendar, I marked the days without laboratories as “CPR lab holiday.” CPR now counted for 12% of the total grade and was equivalent to an exam. I invited students to let me review their essays before submitting them to CPR. To emphasize the importance of quality essays, I changed the CPR assignment grading weights to place more emphasis on the text entry grade. I also began using Turnitin.com (www.turnitin.com) as an instructional tool to help students check their work for plagiarism; each student was required to submit the essay to Turnitin.com as a plagiarism check, and then resubmit to CPR. In this way, I wasn't the "Plagiarism Police," but I was allowing students to check their own papers first. I also took about 5 minutes per week from lecture to discuss common grammar mistakes and included an extra question on grammar on their exams. I did meet all the requirements for the "W" course, but one—I didn't teach chemistry majors—and so in future semesters I discontinued the emphasis on teaching grammar in class, although grammar tips continued to be included in the syllabus.

Spring 2005
I continued the above activities and made increased efforts to communicate explicitly the motivation and policies for using CPR. I added a copy of my teaching philosophy in my syllabus. I spent class time to emphasize that CPR was one of several alternative ways for students to learn and demonstrate their learning, so that students could struggle as test-takers and still do well in the course. I stated clearly that CPR was an assessment—a demonstration of learning—in its own right, not simply a way to study for an exam.

Fall 2005
I continued to share my philosophy on teaching with my students. I took additional classroom time to show students how to log in to both CPR and Turnitin.com. I used Bloom's taxonomy (Bloom et al., 1979) to help students recognize how important critiquing skills were to their future. Throughout the semester, I emphasized that most students were novice reviewers and that CPR was a tool to scaffold their reviewing skills. I stressed my willingness to review, and override where warranted, their peers' rating of their essays.

Spring 2006
I continued implementation of CPR as before, with all of the modifications I had previously made. In addition, while my students were working on their first assignment, I added an in-class discussion on strategies for success on the calibration portion of the assignment.

Findings

Research Question 1: What do students think about CPR as a learning tool?

The first part of item 1 on the SALG asked students to indicate whether or not future classes should use CPR. Table 1 presents percentages of students who responded yes or no to this question during each of the seven semesters. The percent of students who believed that future classes should use CPR rose from 43% in Fall 2002 to 71% in Spring 2006. Items 2-5 on the SALG asked students to indicate their agreement with statements about their enjoyment of CPR and about the value of CPR to their learning. Table 2 shows percent response to these items in each of three categories: strongly agree/agree, neutral, disagree/strongly disagree. Graph 1 shows the percentage of those students who agreed or strongly agreed with the items 1-5 for each semester. From the beginning, more students understood the value of CPR for improving their ability to critically review (item 5) and by Spring 2006, even though only 26% of the students enjoyed CPR as an exercise (item 2), 70% of them recognized that CPR helped them hone their reviewing skills.

SALG items 2 through 5 allowed us to break the question "What do students think about CPR?" into several smaller questions. We investigated the relationships among these questions for all semesters. When we examined the data, we found moderate but significant positive correlations each semester among responses to items 2 through 5. Spearman correlation coefficient rho values ranged from 0.48 to 0.70, significant at $p<0.001$ (2 tailed).

In order to investigate the Likert items further, chi square 2x2 contingency tables were produced for each semester by dividing the students into two groups: those that agreed and strongly agreed with an item and those that were neutral, disagreed or strongly disagreed with the item. In the chi-square analysis, we found that the values of $X^2(1)$ between all pairs ranged from 8 to 53 (Table 3), showing that the data were interdependent at $p<0.005$. This interdependence is reflected by the 2x2 contingency table results for each semester (Table 4). Using Spring 2006 data as an example, we saw that of the 60 students

(26%) who reported enjoying CPR, 90.0% indicated that CPR helped them learn chemistry, 78% that it improved their writing and 95% that it improved their critiquing skills; and of the 175 students (74%) who did not enjoy CPR, only 47% thought it helped them learn chemistry, 33% that it improved their writing, and 62% that it improved critiquing skills. Using odds ratios (Graph 2), we found that all students in the study who enjoyed CPR were on average 10 ± 5 (std. dev.) times more likely to think CPR helped them learn more chemistry than those who didn't enjoy CPR, 11 ± 6 times more likely to think CPR improved writing skills, and 9 ± 5 times more likely to think CPR improved critiquing skills than those students who did not enjoy CPR.

We compared the quantitative measurement of student experience with CPR with whether or not students recommended CPR to future classes (Graph 3). The percentage of students with a negative experience (average of <3 on items 2-5) who wanted future students to use CPR (Group 1) stayed relatively small at 11.2 ± 1.5%. Also, the percentage of students who saw some benefit to CPR (average >3 on items 2-5) but did not believe future classes should use it (Group 4) stayed constant at 3.3 ± 0.6%. However with time and the instructor's gained experience, the percentage of students who had a negative experience and hoped that future classes would not have to use CPR (Group 2) decreased, and the percentage of students who had a positive experience and did want future classes to use CPR (Group 3) increased from 25% to 54%. Findings from our qualitative analysis helped to interpret these results.

Research Question 2: What do student comments reveal about the reasons for their acceptance of or resistance to CPR?

Student explanations to item 1 (in response to why students recommend or not that CPR be used in future semesters) provided insight into their acceptance of or resistance to CPR. During the analysis of 1227 explanations, we focused on the statements within each explanation. An explanation could contain one or more statements. For example, "I don't think my peers should grade me, but I thought the overall CPR process was useful in improving writing skills; it also helped me learn chemistry," is one explanation with three statements, one negative and two positive.

Throughout the analysis, we let categories emerge from the statement or statements in the explanations with a focus on what students were actually saying. We collected positive categories in three groups: (A) CPR helped learning in the ways that the instructor intended, (B) CPR was beneficial to student development in ways that the instructor did not explicitly intend and (C) CPR was viewed positively for reasons not necessarily tied to learning. Four subcategories of A, enhanced learning of critical content, enhanced critical thinking skills, enhanced writing skills, and helped link chemistry to life were benefits that the instructor had intended for her class. Three subcategories of B, prepared students for future and professional life and developed time management and communication skills were benefits of CPR that the students brought to our attention and the instructor had not intended. Finally, two subcategories of C, better than labs and an alternative means to show learning were grouped as benefits that were unrelated to learning. Table 5 presents the percentages of positive categories for each semester.

Negative statements fell into four categories: (A) CPR did not help learning, (B) Complaints about grading and peer review, (C) Writing does not belong in a chemistry class, and (D) Other reasons for not liking CPR. Table 6 presents the percentages of negative categories for each semester.

The following student response illustrates our analysis: "I don't think my peers should grade me, but I thought the overall CPR process was useful in improving writing skills. It also

helped me learn chemistry." This answer contains three statements falling under three categories: a negative category (complaints about grading and peer review) and two positive categories (enhanced writing skills and enhanced learning of critical content).

Results indicated that the despite decreasing from the first semester to the second, the percentage of positive statements steadily increased from Spring 2003 until the final semester (Table 7). In fact, the majority of statements fell under positive categories in the last three semesters (51% in Spring 2005, 55% in Fall 2005, and 56% in Spring 2006). In the next section, we explain and illustrate the three groups of positive categories and four negative categories. The percentages for each semester are presented in Tables 5 and 6.

Category Analysis of Positive Statements

Category A (CPR helped learning in the ways that the instructor intended)

Some students whose statements fell under this group indicated that CPR helped them learn critical course content while some commented that CPR improved writing skills. In fact, these two

subcategories had the highest percentage of positive statements in each semester, and although the percentage fluctuated, it remained fairly high. Some students observed that in order to write about a topic, you must understand and learn it: "With CPR there's no way around learning the information. To write a good paragraph, you're going to have to know what you're talking about;" "CPR really helped me understand the topics. It reinforced the material by forcing me to teach myself and explain it to others through writing. It was very helpful."

One student wrote:

> Calibrated Peer Review forces the student to look into the topic way more closer [sic] than what he or she would do out of a textbook. I know the CPR has tremendously helped me understand each topic better although I didn't exactly enjoy it so much.

Some students commented that CPR helped them develop not only general writing skills, but specifically scientific writing skills. In fact, some pointed out that CPR was the first time that they had to practice discipline-specific writing at all: "I'm an engineering student and this was the only time I was ever really exposed to writing this semester so it kind of practiced my writing skills;" "Even though I didn't want to use it, it was my first exposure to technical writing."

Students also noted that reviewing others' work helped their understanding and enhanced their critical thinking skills: "Critiquing the other students helps you see what you did wrong and helps you understand better;" "It does help you learn how to look critically at other people's and even your own writing."

Although a lesser percentage, some students actually commented that writing helped link chemistry to life: "CPR assignments help students to better connect chemistry to aspects of real life;" "CPR helps with writing skills and also helps you relate chemistry topics with things in the outside world!"

Category B (CPR was beneficial to student development in ways that the instructor did not explicitly intend)

While statements in the previous group described the learning benefits for which CPR was designed, a small percentage of students commented on learning that had not been explicitly intended. For example, some students noted that using CPR helped them to

prepare for future and professional life: "CPR should be required for all science classes because it helps the student frame their work in the proper perspective of that field." Others pointed out that CPR helped develop specific skills such as time management and communication skills: "If anything, it teaches kids to be responsible with their assignments and time deadlines and to incorporate other subjects (writing) with Chemistry."

Category C (CPR was viewed positively for reasons not necessarily tied to learning) Some of the positive statements were unrelated to student learning and development. Some students simply noted that doing a CPR assignment was preferable to doing a lab. While the percentage of students who made this statement was high in Fall 2002 (25%) it decreased to 0-5% in the other semesters. Some students noted that CPR helped their grade and appreciated that it was an alternative means of demonstrating what they were learning: "CPR allows another opportunity, other than exams, to test your knowledge on the subject being tested on. Additionally, it provides another way to boost your grade." The percentage of students who noted that CPR was helpful as an alternative method of assessment increased from 2002 to 2006.

Category Analysis of Negative Statements

Category A (CPR did not help learning)

Students who noted that CPR did not help their learning indicated that it did not help them develop their writing skills or learn chemistry. The percentage of this category varied but did slightly decrease from 2002 to 2006. Although in most cases, students simply made statements such as "it did not improve my writing skills" without further explanation, statements under categories B and C described below helped explain student resistance to CPR.

Category B (Complaints about grading and peer review)

Statements in this category reflected student expectations that their grades should be the domain of the instructor. While some complaints were about CPR's grading system in general, such as "The grading system could be made more fairly" and "The way they are graded is not fair," some students reported being uncomfortable with the idea of someone at their same knowledge level assigning a grade: "Why would people comment on papers and grade them when they are in the process of learning the material themselves?" Students indicated a belief that the grading was too subjective and that judgment of writing was only an opinion and that they should not be penalized if their opinion was different from their peers. For example, one student wrote: "They ask you to grade the essays, but then your opinion of how that person did would be wrong. I just don't see how your opinion could be wrong." Another student wrote:

> The way that the grading system works is due very much to personal discretion and open to ones own interpretation. There were times that I would find something wrong and marked it that way yet had reasoning behind it and had to redo the entire reviewing of that essay.

Category C (Writing does not belong in a chemistry class)

Statements in this category reflected student expectation that writing belongs in English, not in science classes. Some indicated that writing and peer critique are not necessary for chemistry: "I have never viewed chemistry as being a subject where you write things;" "We could take English to learn how to write correctly;" "I didn't understand why writing a paper and grading other students papers had anything to do with chemistry." In Fall 2004, when the instructor was attempting to make her class a "W" course, 21% of the negative statements were in this category. Before then, when CPR assignments were a part of the lab and worth on 3-5% of the grade, students made fewer statements that fell under this

category. After Fall 2004, the comments again decreased because of instructional modifications.

Category D (Other reasons for not liking CPR)
The largest percentage of negative statements fell into this category consisting of statements about CPR that had, on the surface, little to do with learning. Students wrote that CPR was too time consuming, harmed their grade and was worse than labs, caused or added to stress, and that meeting deadlines was a problem. In contrast to the first three categories, statements in category D could be heard about almost any course requirement. They reflect a need to help students accept that learning requires time, is often stressful, and that deadlines are a part of life. What we cannot say for certain based on this analysis is whether the time-consuming nature of CPR prevents students from seeing its benefit to learning, or if not seeing the benefit leads to the conclusion that it takes too much time. We

can say, from a separate survey, that 94±2% of the students over seven semesters said the amount of time allowed for CPR was adequate.

Further Analysis of Quantitative Data Using Supporting Qualitative Data Before proceeding to the third research question, let us revisit our earlier quantitative analysis of student experience with CPR as it relates to whether or not the students recommended CPR to future classes (Graph 3). After conducting the qualitative analysis, we counted the number of positive and negative statements for each group (Table 8 and Graph 4) and the results were surprising. We had interpreted students in Group 1 (whose responses to items 2-5 indicated a negative experience but who said that future students should use CPR) to be communicating a desire to make future students "suffer" as they had. The qualitative analysis did not support this interpretation. With the exception of the first semester, students in Group 1 made three times more positive statements than negative statements. Thus, it appears that this group is not saying "if we had to do it so should they." Rather, they are indicating that while it had not enhanced their personal learning experience, they could see that it could be a beneficial learning tool. Similarly, students in Group 4 (whose responses to items 2-5 indicated a positive personal experience but who did not indicate that future students should use CPR) made three times more negative statements than positive ones. Students in Group 2 who had an overall negative experience with CPR and who did not want future classes to do CPR gave six times more negative statements than positive ones, and students in Group 3 with an overall positive experience with CPR and who did want future classes to do CPR gave seven times more positive statements than negative ones.

Research Question 3: Why and how did the instructor persist?
This section presents the instructor's reflection (in her own voice) of her use of CPR throughout the semesters. This detailed report reveals how and why she persisted in using CPR in her classes.

General Reflection
If I had been attuned to the literature on introducing innovative learning tools to the classroom, I would have expected the resistance I experienced. However, the level of student unhappiness was totally unexpected. Using the SALG feedback and simple conversations with students, I slowly began to incorporate changes into the class to lessen student angst by intuitively using the process of reflection-in-action (Schön, 1983). Table 9 shows the reflective path I took combined with actual qualitative data gleaned from our study, even though I did not explicitly study the data at the time.

Fall 2002
I knew CPR was an excellent program, but I was a novice user. I assumed it was self-explanatory and that my students were so computer-savvy that they would have no problems. I also presumed that the grading part of the program would not need any intervention. However, as I listened to the students and read SALG comments, I learned that students were confused about how CPR worked and how the assignments were graded.

Spring 2003
I realized I had naively assumed that the instructions available on the CPR website were sufficient to explain the process, but student complaints indicated otherwise. So, before the semester began, I prepared an extensive four-page handout that thoroughly discussed how the system worked, how to do well, and how to read the grading page. After listening to the students, I also began to emphasize that I would help anyone with problems with the software. I started to consider CPR as an alternative for showing chemistry proficiency and I discussed this in class. CPR was only worth 5% of their grade at that point, but at the end of the semester, there were some student comments stating that CPR enhanced learning. I

noticed that although the complaints about instruction diminished, grading complaints were still high.

Spring 2004
At this point, I worked very hard to show that the grading was fair. I invited students to send me an email requesting a grade check if they thought they were graded unfairly. I began to proactively look at student grades and change them when deserved. I wanted to help those students who thought, and reported, that they were not learning from CPR and I thought that if the assignments were written by me, students would feel more comfortable. Thus, I began to write my own assignments. The results were encouraging, as I noticed that there were no grading complaints, outside of those related to peer reviewing. Now I wanted to address the objections that writing was not fit for a chemistry class, which was also a common theme in student criticisms.

Fall 2004
I began the semester by stating that my class was a "writing intensive" class and increased the CPR component to 12% of the grade, equal to that of an exam. I noticed that there was an increase in student comments stating that CPR helped their writing skills, probably due to the extra emphasis I placed on teaching grammar that semester. Students started commenting more that CPR helped bad test takers. However, students still said that writing was not appropriate for a chemistry class.

Spring 2005
In my syllabus, I continued to emphasize my policy of incorporating other ways that would enable my students to be successful. I added my teaching philosophy to the syllabus to share my motivation for my teaching practices and establish trust between my students and me. My teaching philosophy stated that 47% of the grade was from work other than exams and that CPR was not merely preparation for exams, but was an actual grade. By the semester's end, students knew CPR could help their grade if they were bad test takers. In addition, statements indicating that CPR enhanced learning of critical content increased. However, students also realized that the CPR grade was important and could actually harm their average, which led to more negative comments regarding grading issues, including peer review problems. Meanwhile, comments suggested that students still did not think that writing had a place in a chemistry class.

Fall 2005

In order to assist students further in technological issues, I gave a short presentation on how to log into CPR in class. In addition, to address the place of writing in chemistry, I used the principles of Bloom's Taxonomy to illustrate the importance of writing and critiquing in chemistry and for future careers. Throughout the semester, I emphasized that students were novice reviewers and that I would review student papers before submission if asked. I also assured them I would regrade their papers if necessary. For the first time, I noticed a decrease in comments suggesting that writing was not fit for a chemistry class and complaining about general grading issues.

Spring 2006
I was still concerned about student resistance to the grading process, so not only did I demonstrate how to write an essay for CPR, I also showed the students how to critique others using a grading rubric. Finally, students no longer complained about grading and comments suggesting that writing was not fit for a chemistry class lessened. Meanwhile, there was an increase in comments stating that CPR enhanced learning.

Discussion

As the findings indicate, the answers to the research questions (What do students think about CPR as a learning tool? What do student comments reveal about the reasons for their acceptance of or resistance to CPR? How and why did the instructor persist, particularly in the face of initial student resistance?) are closely connected. The quantitative results indicated that initially the majority of students did not like CPR and did not believe that it helped their learning. The qualitative analysis revealed that this student resistance to CPR was accompanied by a strong sense that writing and reviewing have no place in a chemistry class. In addition, student resistance was exacerbated by student distrust of the ability of their peers to review fairly and accurately.

However, despite their initial resistance, student perceptions changed over time and became more positive. Over the seven semesters, the percentage of students in each class who enjoyed CPR rose from 11% to 26%; those who recognized that CPR helped in learning chemistry rose from 21% to 58%; those who perceived a gain in writing skills rose from 28% to 45%; and those who recognized that they gained critiquing skills rose from 43% to 70% (Table 2 and Graph 1). Simultaneously, the percentage of positive statements steadily increased from Spring 2003 until the final semester (Table 7). In fact, the majority of statements fell under positive categories in the last three semesters (51% in Spring 2005, 55% in Fall 2005, and 56% in Spring 2006).

It is also encouraging that despite the resistance to CPR, the percentage of positive statements indicating that CPR enhanced writing skills did not fall under 28% in any semester and even went up to 51% in Fall 2004, when the instructor attempted to have her course classified as a university "W" course (Table 5). Meanwhile, the percentage of positive statements indicating that CPR enhanced learning of critical content did not fall under 20%.

Since the increase in overall positive comments happened as the instructor modified her implementation strategies, we relate the former to the latter. Akerlind and Trevitt (1999) suggest that an innovative technological tool may impact students directly through its use and indirectly through its effect on other aspects of the course, which is what happened in the instructor's course. Through the use of CPR, the instructor started changing not only the structure and focus of the course itself, but also how she presented herself as an educator, such as sharing her own teaching philosophy with her students. While the instructor had not been doing thorough analysis of SALG data until 2006 when we began this study, she was

scanning the results and reading student comments. Her own belief in the value of CPR was strong enough to be encouraged by positive comments and to resist giving up. The instructor's practice of collecting student perception data through SALG kept her informed about student resistance and anxiety so that she could make targeted improvements. This process, called reflection-in-practice (Schön, 1983) was used intuitively by the instructor. Although initially surprised by the students' negativity toward CPR, she changed the class structure and her teaching style to alter student attitude. She used negative comments to guide her future use of CPR. She recognized that, until the introduction of CPR, it was rare for chemistry students to be asked to write essays, and rarer still for them to be expected to review each others' writing. Thus, through the lens of the Theory of Perceived Attributes (Rogers, 2005), CPR did not have "compatibility": The nature of CPR assignments ran counter to what students expected. The comments made her realize that CPR had neither relative advantage nor "observability" for the students—students could not observe and did not realize its benefits. Thus, she needed to help students see its value and the abilities it fosters. For example, instead of simply assuming that students would recognize the importance of learning to review, she tried to create "change through persuasion" (Akerlind & Trevitt, 1999, p. 101) by discussing the importance of learning to review with them during class and connecting it to the kinds of careers they would want to have in the future. She also started giving advice about how to succeed in CPR assignments, reassuring the students that she would help them with technical issues if necessary, and providing more guidelines on the software and examples of how to use it during class. After the first two semesters, she became more involved with the CPR software by creating her own assignments and provided support that would relieve student anxiety about peer grading. She became much more intentional about communicating to the students what they would gain from completing CPR assignments and tried to instigate "attitudinal and conceptual change" (Akerlind & Trevitt, 1999, p. 101) by presenting her deep-seated student-centered teaching philosophy in her syllabus and abiding by that philosophy to obtain student trust.

This study demonstrated the power of a mixed methods approach when we first correlated a quantitative measurement of student experience (the numerical average of Likert scale items 2-5) with their recommending CPR to future classes. From the quantitative data alone, we were prepared to say that students who did not have an overall positive CPR experience and wanted future classes to do CPR, were actually saying "if we had to, then they have to," in a negative way. This was not the case, as 80% of their comments were positive (Graph 4). Supporting qualitative data prevented us from misinterpreting the data.

While it is not necessary for students to "like" a particular learning tool in order to benefit from it, the correlational analysis of the data demonstrated that students who enjoyed CPR reported that they received 4-22 times more benefit (with regard to their learning, writing skills and critiquing skills) from it than those who did not. Although only a small percentage of the students admitted that they enjoyed CPR, we can say that when students understand the value of CPR, they are more likely to see that it improves learning, writing, and critiquing skills. But why was student resistance so persistent despite the changes that the instructor made and the increase in positive student reactions? Akerlind and Trevitt (1999) suggest when an innovative tool is introduced, students must undergo a paradigm shift in their perception of learning and readjust their notions about the roles of student and instructor, which all lead to negative reactions. These perceptions are not easy to change, since they are culturally rooted beliefs that begin in elementary school (Cuban, 1993).

This study has implications for the introduction of any teaching innovation. Akerlind and Trevitt (1999) suggest that instructors must expect student resistance to such innovations and be ready to work through the student resistance to innovations and not be discouraged. In addition to this, it is important that students be coached through the adaptation and have

enough guidance regarding the software itself, since perceived complexity of a software program is negatively correlated with perceived enjoyment and perceived usefulness of the tool (Cheung & Huang, 2005). Our instructor believed in the benefits of CPR and immediately began to provide more help to the students in the next semester, but some aid was more beneficial than others in decreasing negative responses. She found that direct face-to-face help, for example, in-class demonstrations and office hours for aiding with software issues, was much more beneficial to the students than indirect help, for example, extensive handouts.

When the instructor in our study explicitly conveyed to the students the value of writing and peer critiquing for learning chemistry and for their future careers and made the CPR assignments worth a significant part of their grade, students reported a much more positive experience with this particular innovation. This study demonstrated that students are willing to take a more active and responsible role—even when the innovation runs counter to their expectations—when they perceive the value of such engagement and are supported in their efforts.

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Table 1
Item1: "Do you think that future classes should do CPR™?"

Semester	No. of Responses	Yes	No
Fall 2002	218	43%	57%
Spring 2003	188	36%	64%
Spring 2004	219	44%	56%
Fall 2004	201	57%	43%
Spring 2005	243	59%	41%
Fall 2005	209	68%	32%
Spring 2006	237	71%	29%

Table 2 - Likert Scale Data for Items 2-5

Item2: "I enjoyed doing the CPR assignments."

Semester	Strongly Agree/Agree	Neutral	Disagree/Strongly Disagree
Fall 2002	11%	17%	72%
Spring 2003	6%	16%	79%
Spring 2004	10%	23%	66%
Fall 2004	18%	22%	59%
Spring 2005	19%	24%	58%
Fall 2005	20%	25%	55%
Spring 2006	26%	27%	48%

Item3: "The CPR assignments helped me learn some chemistry."

Semester	Strongly Agree/Agree	Neutral	Disagree/Strongly Disagree
Fall 2002	21%	26%	53%
Spring 2003	20%	18%	62%
Spring 2004	23%	20%	57%
Fall 2004	34%	24%	41%
Spring 2005	46%	21%	33%
Fall 2005	45%	24%	31%
Spring 2006	58%	21%	21%

Item4: "The CPR assignments helped me improve my writing skills."

Semester	Strongly Agree/Agree	Neutral	Disagree/Strongly Disagree
Fall 2002	28%	31%	42%
Spring 2003	32%	29%	40%
Spring 2004	28%	27%	45%
Fall 2004	39%	23%	38%
Spring 2005	41%	24%	35%
Fall 2005	40%	27%	32%
Spring 2006	45%	31%	25%

Item5: "The CPR assignments helped me learn to critique my own writing and that of others."

Semester	Strongly Agree/Agree	Neutral	Disagree/Strongly Disagree
Fall 2002	43%	24%	33%
Spring 2003	39%	27%	34%
Spring 2004	51%	24%	25%
Fall 2004	60%	19%	20%
Spring 2005	64%	11%	26%
Fall 2005	64%	14%	22%
Spring 2006	70%	21%	9%

Table 3
Chi-Square Data for Items 2-5 for Each Semester

	Fall 2002	Spring 2003	Spring 2004	Fall 2004	Spring 2005	Fall 2005	Spring 2006
$X^2(1)$ between enjoying CPR and learning chemistry	8.0 (p<0.005)*	14.2	41.6	33.3	42.4	22.5	34.1
$X^2(1)$ between enjoying CPR and improving writing	14.1	13.7	34.7	48.5	38.5	23.1	36.9
$X^2(1)$ between enjoying CPR and improving critiquing	16.4	9.0	9.4	12.6	24.6	10.0	23.7
$X^2(1)$ between learning chemistry and improving writing	42.9	41.6	38.4	40.1	49.0	36.2	45.0
$X^2(1)$ between learning chemistry and improving critiquing	21.3	22.3	18.0	31.5	49.5	18.2	31.8
$X^2(1)$ between improving writing and improving critiquing	31.1	45.7	52.4	33.9	51.9	42.4	52.6

* All the rest were interdependent at p<0.001.

Table 4
Chi-Square 2x2 Contingency Table Data Comparing Students Who Enjoyed CPR to Students Who Did NotEnjoyCPR

	Fall 2002	Spring 2003	Spring 2004	Fall 2004	Spring 2005	Fall 2005	Spring 2006
Students who enjoyed CPR	11% (N=23)	6% (N=11)	10% (N=22)	18% (N=37)	19% (N=45)	20% (N=41)	26% (N=60)
CPR helped them learn chemistry	43%	64%	77%	76%	89%	78%	90%
CPR improved their writing	61%	82%	82%	89%	82%	73%	78%
CPR improved critiquing skills	83%	82%	82%	86%	96%	85%	95%
Students who did not enjoy CPR	89% (N=193)	94% (N=176)	90% (N=194)	82% (N=164)	81% (N=198)	80% (N=168)	74% (N=175)
CPR helped them learn chemistry	18%	16%	16%	26%	35%	37%	47%
CPR improved their writing	24%	27%	22%	27%	32%	32%	33%
CPR improved critiquing skills	38%	34%	47%	55%	56%	59%	62%

Table 5
Category and Subcategory Data for Positive Statements

Semester	Total	A1	A2	A3	B1	B2	B3	C1	C2
Fall 2002	69	33%	10%	28%	1%	3%	0	25%	0
Spring 2003	35	31%	11%	49%	0	6%	3%	0	0
Spring 2004	82	20%	18%	45%	0	9%	1%	5%	2%
Fall 2004	72	29%	11%	51%	1%	0	1%	0	7%
Spring 2005	121	44%	9%	28%	1%	0	7%	1%	10%
Fall 2005	96	36%	10%	30%	4%	5%	0	1%	14%
Spring 2006	116	32%	13%	34%	1%	6%	0	3%	11%
Total	591								

A1= enhanced learning of critical content
A2 = enhanced critical thinking skills
A3 = enhanced writing skills
B1 = helped link chemistry to life
B2 = prepared students for future and professional life
B3 = developed time management and communication skills
C1 = better than labs
C2 = an alternative means to show learning

Table 6
Category and Subcategory Data for Negative Statements

Semester	Total	A	B1	B2	C	D
Fall 2002	162	21%	14%	6%	6%	53%
Spring 2003	152	26%	10%	3%	10%	51%
Spring 2004	131	17%	8%	5%	14%	56%
Fall 2004	105	17%	2%	6%	21%	54%
Spring 2005	115	14%	15%	5%	16%	50%
Fall 2005	80	21%	7%	5%	9%	58%
Spring 2006	93	11%	5%	10%	4%	70%
Total	838					

A = CPR did not help learning
B1 = complaints about grading
B2 = complaints about peer review
C = writing does not belong in a chemistry class
D = other reasons for not liking CPR

Table 7
Percentages of Positive and Negative Statements

Semester	Total Statements	Positive Statements	Positive Statements (%)	Negative Statements	Negative Statements (%)
Fall 2002	231	69	30%	162	70%
Spring 2003	187	35	19%	152	81%
Spring 2004	213	82	38%	131	62%
Fall 2004	177	72	41%	105	59%
Spring 2005	236	121	51%	115	49%
Fall 2005	176	96	55%	80	45%
Spring 2006	209	116	56%	93	44%
Total	1429	591		838	

Table 8
Quantitative&QualitativeDataRegardingStudentExperiencewithCPR&ItsPromotionforFutureUse

Semester	No. of Student Responses	Group 1 (%) (P/N)*	Group 2 (%) (P/N)*	Group 3 (%) (P/N)*	Group 4 (%) (P/N)*
Fall 2002	218	11.0 (10P/11N)	48.2 (19P/85N)	25.2 (42P/13N)	3.2 (0P/7N)
Spring 2003	188	11.2 (12P/2N)	56.4 (10P/92N)	22.9 (25P/7N)	3.2 (1P/5N)
Spring 2004	219	10.0 (10P/3N)	47.0 (10P/81N)	26.5 (48P/7N)	3.7 (2P/6N)
Fall 2004	201	13.4 (20P/3N)	35.3 (8P/59N)	42.4 (66P/5N)	2.0 (1P/3N)
Spring 2005	243	9.5 (15P/5N)	35.0 (12P/70N)	42.4 (84P/8N)	3.3 (4P/6N)
Fall 2005	209	12.9 (20P/6N)	25.8 (7P/46N)	47.8 (78P/4N)	3.8 (4P/8N)
Spring 2006	237	9.7 (17P/4N)	22.4 (10P/42N)	54.9 (111P/19N)	3.8 (1P/6N)

Notes. * P is the number of positive statements; N is the number of negative statements.
The percentages do not add to 100% since there were students who averaged exactly 3.00 on items 1-4 who were omitted and not all students responded to every question.

Group 1: Students with negative CPR experience, yet want future classes to do CPR
Group 2: Students with negative CPR experience, and do not want future classes to do CPR
Group 3: Students with positive CPR experience, and want future classes to do CPR
Group 4: Students with positive CPR experience, yet do not want future classes to do CPR

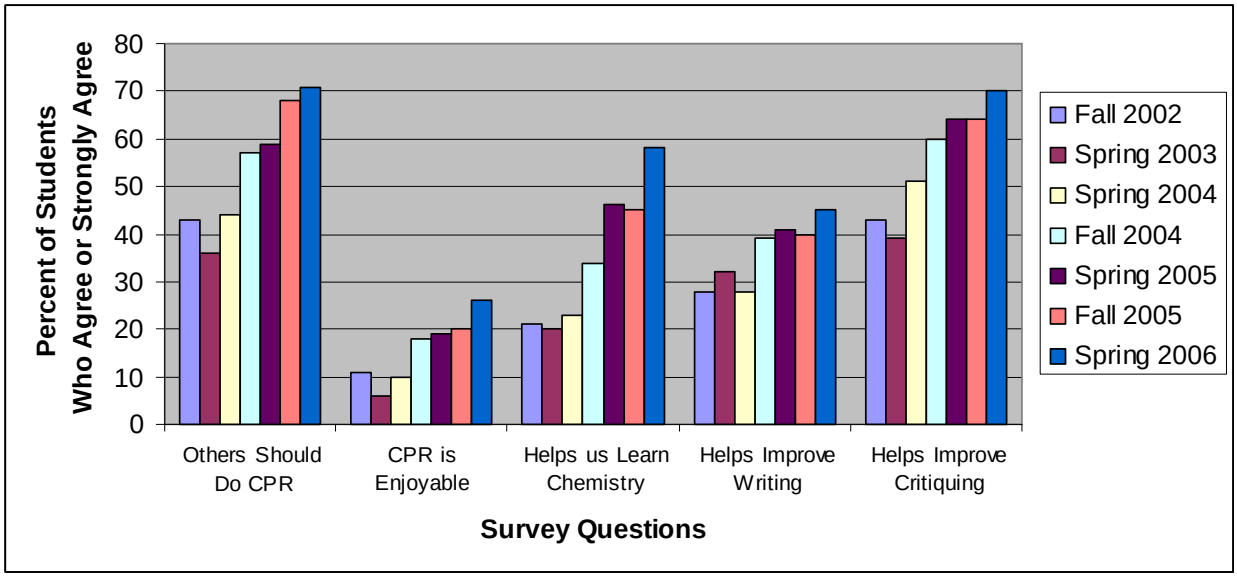
Table 9
Timetable Summary Demonstrating Reflective Practice in Action

Semester	Student Criticism Addressed	Instructor Actions	Major Outcomes
Fall 2002	•Lack of instruction •Grading complaints		•Lack of instruction (9%N)* •Total grading issues (20%N) •Did not enhance learning (13%N)
Spring 2003	•Grading complaints •Enhanced learning	•Prepared 4 page handout including extensive grading explanation	•Lack of instruction (2%N) •Total grading issues (13%N) •Enhanced learning (5%P)
Spring 2004	•Writing not fit for subject	•Proactively changed student grades when deserved •Began writing assignments	•General grading issues (0%N) •Enhanced learning (7%P) •Writing not fit for subject (20%N)
Fall 2004	•Writing not fit for subject	•Stated class was "writing-intensive" •Increased CPR's worth to an exam grade	•Writing not fit for subject (23%N) •Helped bad test takers (5%P) •Enhanced learning (10%P)
Spring 2005	•Writing not fit for subject •Grading Issues	•Emphasized teaching philosophy, 47% of grade is not from exams, and CPR is a grade in its own right	•General grading issues (16%N) •Writing not fit for subject (20%N) •Helped bad test takers (10%P) •Enhanced learning (23%P)
Fall 2005		•Emphasized students are novice reviewers; essays would be regraded when asked •Began to review student papers before submission when asked •Used class time to demonstrate CPR and show importance of writing/critiquing for future with	•General grading issues (8%N) •Writing not fit for subject (8%N) •Helped bad test takers (4%P) •Enhanced learning (18%P)

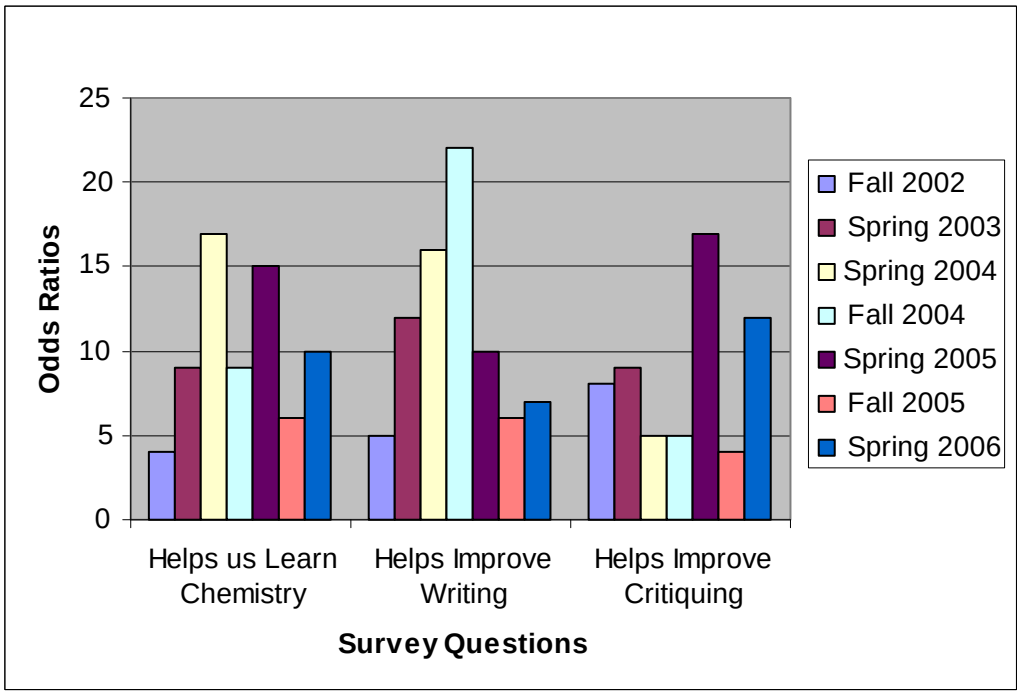
	Bloom's Taxonomy		
	•Grading Issues		
Spring 2006	•Used class time to demonstrate how to critique	→	•General grading issues (0%N) •Writing not fit for subject (4%N) •Helped bad test takers (7%P) •Enhanced learning (19%P)

* %N is the percentage of negative statements; %P is the percentage of positive statements.

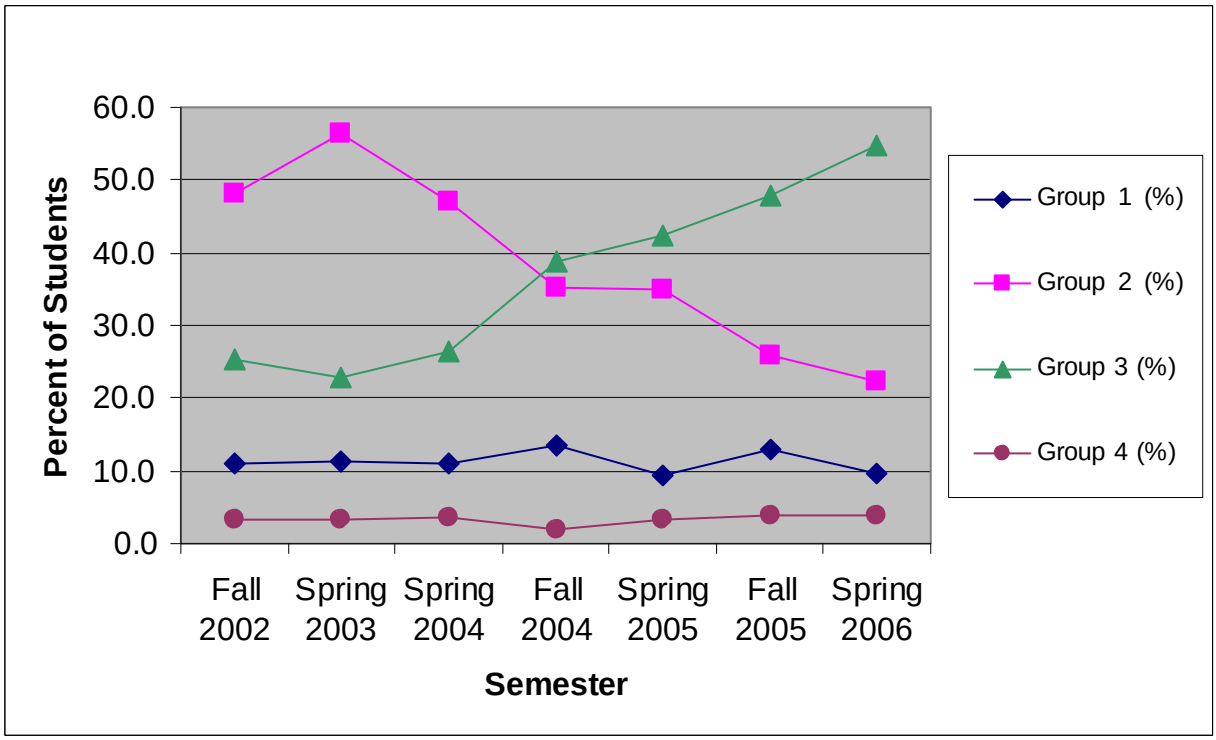
Graph 1
Student Assessment of Learning Gains (SALG) Results on How Students View CPR



Graph 2
Odds Ratios Derived from Chi-Square 2x2 Contingency Tables Comparing Benefits to Students who Enjoyed CPR to Those Students who Did not Enjoy CPR

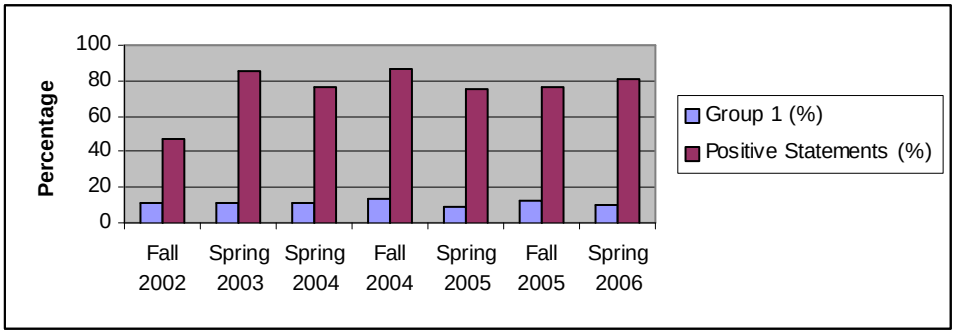


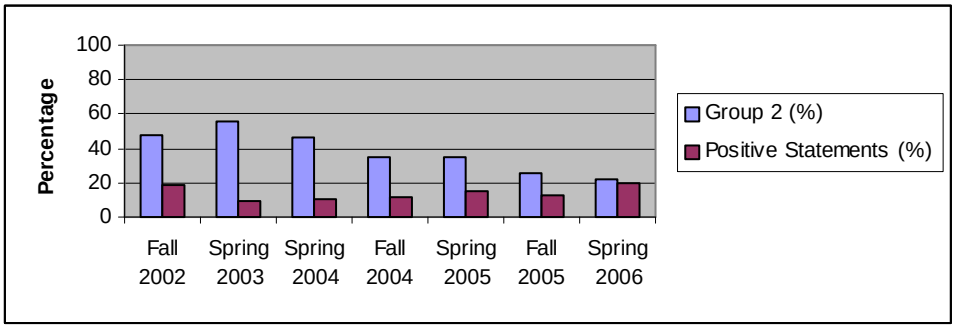
Graph 3
The Relationship Over Time Between Student Experience with CPR and Their Promotion of CPR for Future Classes

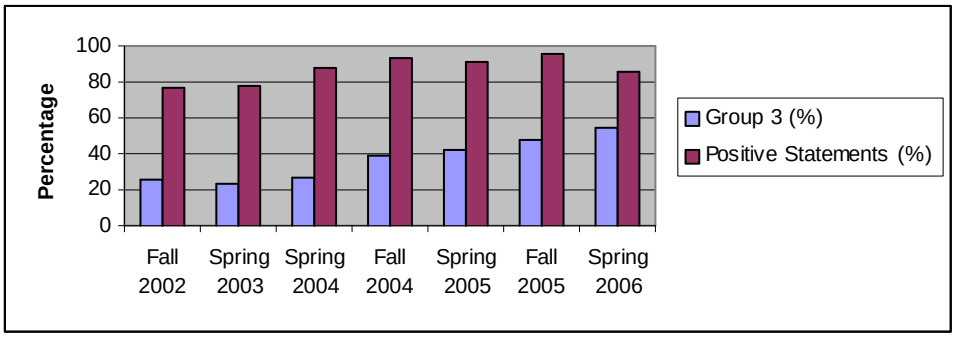


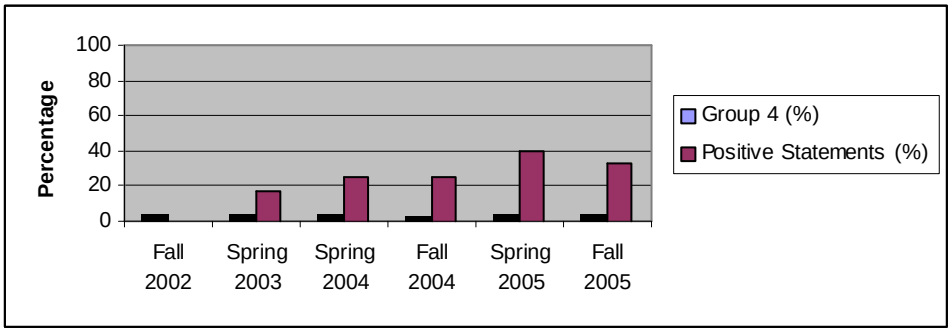
Group 1: Students with negative CPR experience, yet want future classes to do CPR
Group 2: Students with negative CPR experience, and do not want future classes to do CPR
Group 3: Students with positive CPR experience, and want future classes to do CPR
Group 4: Students with positive CPR experience, yet do not want future classes to do CPR

Graph 4
The Relationship Over Time by Group Between Student Experience with CPR Determined Quantitatively and Whether or Not They Promote CPR for Future Classes and Their Percentage of Positive Statement









Group 1: Students with negative CPR experience, yet want future classes to do CPR
Group 2: Students with negative CPR experience, and do not want future classes to do CPR
Group 3: Students with positive CPR experience, and want future classes to do CPR
Group 4: Students with positive CPR experience, yet do not want future classes to do CPR