

Using Formative Writing Assignments to Enhance Student Learning in a First Year Chemistry Class

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Abstract: - We describe the implementation of formative written assignments that enhanced student learning in a General Chemistry course. The formative written assignments consisted of one-minute papers, student feedback sheets, and exploratory content questions (ECQ) that were randomly implemented at any time during a large chemistry lecture. The formative assignments were the only innovations in the standard delivery of a general chemistry course typically offered in the Department. Student's course evaluations and formative feedback suggest a positive response to the formative written assignments. Further evidence of enhanced performance in the course due to formative written assignments is provided by comparisons of total raw scores of students that took the course with the scores obtained in previous offerings of the course that did not incorporate formative written assessments.

Key-Words: - First-year undergraduate, Formative assessment, Exploratory content questions (ECQ), Student feedback, One-minute paper, Active learning

1 Introduction

First year science students need to develop new strategies for learning in the university context [1]. A typical learning strategy of many first year students is to memorize specific units for an exam, but they have difficulties carrying forward what they had learned at the beginning of the course over the entire semester [2-4]. Faculty in the Chemistry Department at Simon Fraser University (SFU) were concerned that students were not retaining basic chemistry knowledge from their prerequisite courses, that students seemed overly dependent on following direct instructions, and that students did not seem to be connecting their previous chemistry knowledge to new situations such as the laboratory course or the next course [5].

Writing is an important component of the language and learning of science, as well as the acquisition of scientific literacy. When a writing task is structured to promote the development of conceptual understanding rather than recalling facts, knowledge transformation for students may occur [6-10]. The decision to focus on formative writing assignments rather than on factual information was

to encourage student's active learning in a typically passive environment (large lecture course) [11]. Since 2002, SFU began implementing a writing-intensive learning initiative across the curriculum, and the course (CHEM 122) - although not formally designated as writing-intensive (W) - implemented several formative teaching strategies that represented important criteria of W courses [12]. The strategies implemented provided opportunities for students to receive ongoing feedback, and they modeled scientific disciplinary ways of writing and thinking. The writing-intensive learning initiative supported both formative and summative writing components as key elements for student learning.

CHEM 122 was a first year, second semester general chemistry course that consisted of two 50-minute lectures per week, and it was taught in the Fall semesters of 2003 and 2005. The short-term course objective was to provide students with the required foundational chemistry knowledge in order for the students to be able to forecast, explore and solve problems at the next level. The long-term instructional objective was to begin to instill active learning skills so that students could apply their

chemistry knowledge throughout their educational and professional careers.

With the goal of assisting students to be more independent and active learners, the instructor piloted some formative assessment assignments so that students would be more motivated to prepare for class, and to gain feedback that would assist in assessing their learning. There were three types of formative assignments; random exploratory content questions (ECQ) in the lecture, small informal writing-to-learn assignments - such as one-minute papers or framed questions - and feedback sheets about the course.

2 Rationale for Using Formative Assessment in the Lecture Course

Assessment typically falls into two general categories, formative and summative. Formative assessment is assessment **for** learning whereby students are provided ongoing and proactive feedback and evaluation of their strengths and weaknesses. Summative assessment is assessment **of** learning, it is fixed and suggests final judgment. Most university students are only exposed to summative assessment [13].

On the first day of classes, the instructor determined that formative assessment was valued and an integral part of the course. The students had regular summative assessment in the form of a midterm exam, CAPA or LON-CAPA (Learning On-Line Network Computer Assisted Personalized Approach) assignments [14] and a final exam. The formative written assignments were introduced as a new feature of the course that would cover material in previous lectures as well as the current lecture. The students were given an opportunity to choose alternate weights for the ECQ, mid-term and final exam. After some discussion, students collectively negotiated to make the exploratory questions worth 10% of their final grade, and similarly, adjusted the weight of the mid term. In this manner, students were given a voice in the design of the course and the instructor had some buy-in on the formative assignments.

In summary, the two forms of simple written feedback techniques included ongoing written response from students to indicate what they were understanding and having difficulty with, and a series of weekly formative assessment assignments that kept the students actively engaged with their course content.

3 Components of the Formative Written Assessment Assignments

3.1 One Minute Papers

To integrate writing and formative feedback in courses, the instructor used the technique of the one-minute paper described in Harvard Assessment seminars as a “modest, relatively simple and low tech innovations (that) can improve student learning and active participation in class” [15-17]. The one minute paper provided the instructor immediate feedback on how students understood the information covered in the lecture. Students were asked to write about the most important thing that they learned and what was the muddiest point still remaining at the conclusion of the lecture. The students were encouraged to write sincere and thoughtful responses. This was a great success as measured by student’s post-course feedback. This format was used for mid-term feedback during the Fall 2003, and the course was adjusted accordingly during the Fall of 2005. Similar benefits have been documented in the empirical study by Chizmar and Ostrosky [15].

3.2 Feedback Sheets

The instructor also requested course feedback on the last day of class: *“If you were able to design this course, what would you keep, what would you add, and what would you change?”* These questions gave the students the opportunity to take a look at the big picture of the course, reflect on their own learning, and to provide critical and thoughtful feedback. They analyzed what they had been doing for 13 weeks and, based on their own experience, they made suggestions that could be applied to future courses. The responses in general were indeed thoughtful, generous and critical, and reflected that the students recognized the value of this instructional approach even though it demanded much more effort than they had anticipated. Their comments were incorporated into a revision of the next iteration of the course in the Fall of 2005.

3.3 Exploratory Content Questions (ECQ)

The other form of formative assessment consisted of random ECQ including material that would be covered during the week’s lecture. This meant that students had to actively prepare for the lecture. Despite their initial hesitation, students seemed to benefit from this interactive approach. Later in the

semester several students even wanted to increase the weight of the ECQ because they were doing so well on them.

ECQ's were randomly assigned during the lecture for 5 – 10 minutes. Students could get answers to them during the tutorial office hours. They comprised 10% of the grade, but functioned as the primary medium to reinforce active learning study habits for the students. Along with the one-minute papers and written feedback assignments, there were a total of eight ECQ over the thirteen week semester. Previously, it was common for some students to miss lectures and not do the weekly readings, since they knew that they would be re-hashed in the tutorial, or the lectures notes would be posted on-line. With the new approach, students had to attend the lecture. They had to review the material from the previous week and be familiar with the current material since it could be addressed in an ECQ. By shifting more responsibility for preparation to students, the instructor could provide more in-depth weekly lectures and the lectures now covered material beyond the readings. In addition to the lecture, on-line course notes were provided for students, but they did not include summaries of weekly readings.

Over the course of the semester, the ECQ shifted from calculations and problems to writing down and analyzing results in their own words. Even though students had the web-based notes about primary information covered in lecture, students were expected to fill in gaps, answer questions and solve problems posed during the lecture. What is significant about this approach is that students became more motivated to attend the lectures and prepare for weekly readings. They also had to attend the lecture because the ECQ could occur at any time. This encouraged more active student learning in the fairly restrictive instructional setting of a large lecture hall where students tend to be more passive.

4 Assessment and Evaluation of the Formative Written Assessment Assignments

Feedback sheets returned at the end of the semester indicated that students "hated and appreciated" the ECQ because they forced them to keep up with their weekly material. The students reported that the ECQ also helped them to be better prepared and feel less stressed when they came to the midterm and final exam. Many students wanted less random and more regular scheduling of ECQ. One student wrote begrudgingly "the ECQ forced me to study before

class as a result I have a better understanding of the course than I would have if we didn't write ECQ." Another student wrote "I would change the ECQ! Although they made me paranoid and I studied all the time because of them....." and finally, this admission "I would keep everything.... Yes, even the ECQ!" Some student thanked the instructor for the exploratory questions and extra study questions because they revealed that she cared about their successful learning.

Their remarks also suggest that students became more confident about the course material because they had been tested throughout the semester and knew how they had been performing. One student wrote; "At first I didn't like the idea of having ECQ in class, but they made me review the material a lot earlier than I would have, and a lot more often. So I didn't have to cram before the midterm and I wasn't all stressed out."

Feedback is important because it provides concrete evidence of what is learned and what needs to be studied. Therefore, their efforts for studying and reviewing could be more focused and successful. For example one student wrote, "Analytical and methodological teaching made it easier for me to understand things because I did not take Chem 12." This comment suggests that this student felt he could learn by problem-solving and did not have to necessarily rely on his previous background in order to be successful.

We had anecdotal and instructor feedback that suggested that students thought they had learned more because of the formative assignments in the two pilot semesters. However, we wanted to find out whether the formative assignments had any actual quantitative impact on student learning in terms of raw scores on course percentages. The Chemistry Department maintains a course grade data-based developed by Dr. Ralph Korteling that most instructors use to input grades. We were able to get information on 15 of the previous 19 semesters in order to compare grades with the two pilot semesters.

Preparing for ECQ might take time from the students to work on their CAPA or LON-CAPA exercises, which is reflected in the lower average CAPA or LON-CAPA grades attained in those courses in which ECQ were present. However, we are able to show that by doing exploratory questions students were better prepared for their final exam. Table 1 displays the averages of those courses that included ECQ and feedback, the averages of the last 15 courses taught, and the minimum and maximum percentages.

CHEM 122	Pilot courses		All 15 courses (%)	Minimum and maximum (%)
	2003	2005		
CAPA or LON- CAPA	87.7	87.2	88.9	(84.9 - 92.0)
Midterm exam	69.8	72.7	66.5	(58.8 - 78.7)
Final exam	64.2	69.2	58.2	(46.9 - 69.2)
Course Percentage	68.8	71.0	63.9	(56.6 - 71.0)

Table 1. Comparison of course assignment averages over 15 semesters.

While the average of the final exam in the last 15 courses taught (including both classes with exploratory questions and without) was 58.2%, the average of the final exam given in those courses in which the exploratory questions were given, were 64.2% in the first pilot, and 69.2% in the second pilot. The only difference among these courses was the introduction of exploratory questions and asking for student feed back. The final exams had the same level of complexity and the same length.

In general, the average course percentage increased by approximately 5.1% with the introduction of ECQ and feedback. An interesting fact is that the second time the pilot course was taught, the average final grade increased by 2%. The main variation was the increase in the number of one minute type papers which provided formative feedback for the instructor.

Both of the pilot courses were taught in the Fall semesters of 2003 and 2005. We did an informal analysis of the total semester course percentages over fifteen semesters to see if there was any difference in patterns of grades. It is noteworthy to see how that average course percentage did not vary depending on whether the course was taught in the spring, summer or fall semesters prior to the innovations in the two semesters. However, when we included the data from the two courses, we noticed an increase in scores in the two major summative assignments (midterm and final exams).

5 Conclusion

In those semesters in which a higher percentage of courses taught had exploratory content questions and feedback, students tended to get higher averages. This suggests a positive relationship between the

formative assignments and summative assignments. Students seemed to be better prepared for the final exams.

Although a minor component of the total grade (10%) was assigned to the ECQ's and one minute papers, they seemed to provide the greatest motivation for students to keep on top of the course material in a consistent and proactive manner. Students reported in the mid-term's feedback sheets that the ECQ's had affected their study habits. They comprised 10% of the grade, but functioned as the primary medium to reinforce active learning study habits for the students.

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