

IPEL Final Report

1. Title of Project and name of participant(s)

“The Redesign of General Chemistry II to Promote Critical Thinking and Long Term Learning”

Prof. Marie Pomije, Prof. John Thoenke
Department of Chemistry and Geology

2. Purpose: Identify the purpose of your project (one to two sentences). If your work changed in any way from the original proposal – please note.

The project had a two-fold focus. First, the development of online materials intended to motivate and guide the students to review topics from General Chemistry I as required for success in General Chemistry II. Second, the creation of “workshop days” in which the students worked in groups to solve chemistry-related application problems designed to require multi-dimensional (both conceptual and mathematical) critical thinking.

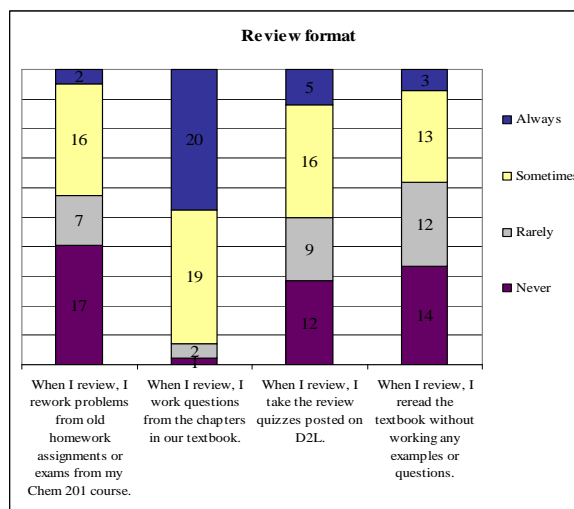
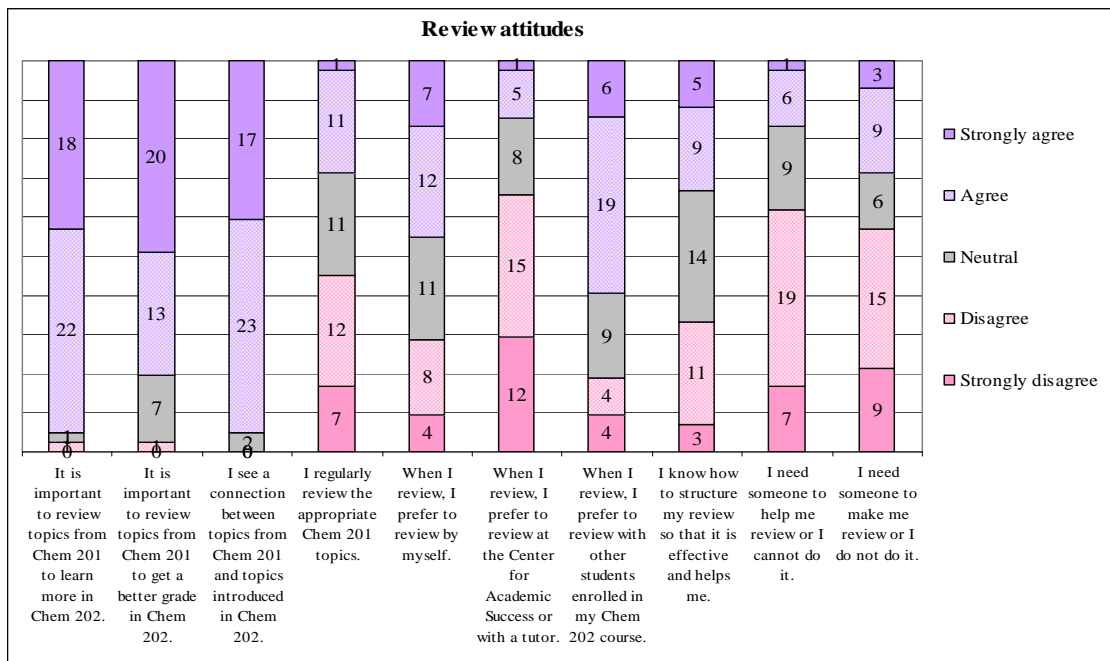
3. Results: Describe how your project enhanced* (or will enhance – if project results are to be implemented in future semesters) students’ critical thinking through one or more of the following activities:

- development, implementation, and assessment of new instructional or curriculum materials
- development, implementation, and assessment of new support mechanisms
- development and implementation of new assessments

The first part of our project involved the development of online quizzes that we made available to students to aid their review of concepts from Chem 201. These quizzes were written to target key areas including writing and balancing chemical equations, performing stoichiometric calculations and identifying shape and bonding phenomena in substances. Each quiz included hints and referrals to appropriate sections of their textbook to further aid and structure student review. An analysis of student use of these quizzes indicated several trends:

- A small number of students actually utilized the quizzes. As noted in the survey below, 50% of the respondents (21 out of 42) indicated they had used a quiz.
- Towards the latter part of the semester, student use of the quizzes increased somewhat.
- The students who did utilize this material generally scored poorly on it; averages were typically below 50%.

To gain some insight into our student’s perceptions about reviewing prior material we developed a survey tool that we made available to students on D2L. The outcomes are presented below:



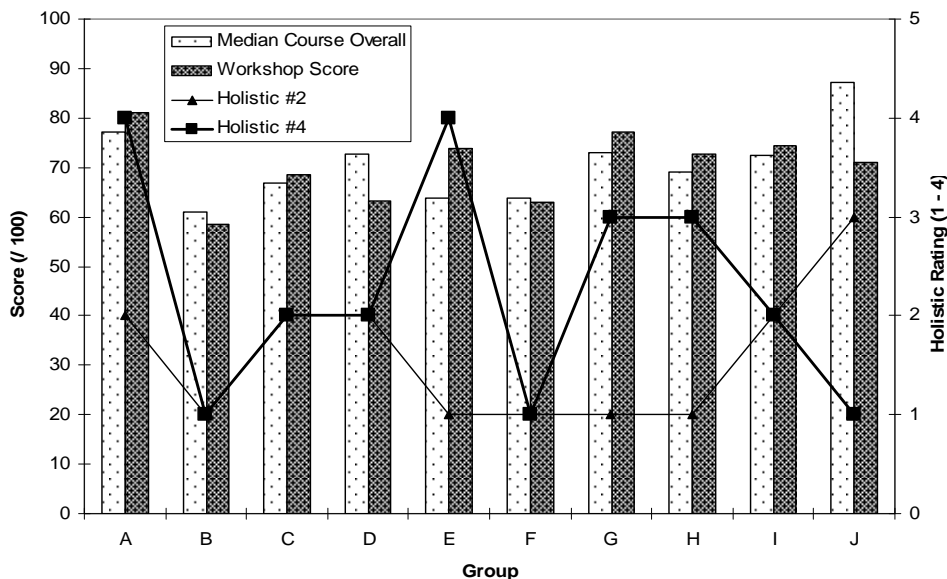
- 42 of the 106 students who completed the course (40%) responded to this survey.
- Approximately 75% of the respondents acknowledged the importance of review and “saw” connections to concepts presented in the prerequisite course.
- However, only 30% of the respondents reported regular review of the appropriate material and comfort with their ability to structure the review productively.
- The majority of respondents (60%) preferred to review with classmates rather than using CAS tutors (14%) or reviewing alone (17%).
- The mode of review favored working problems from the textbook. (Notably, many of these problems have answers supplied in an appendix or student solutions manual). However, other modes such as the online quizzes and rereading were also used.

In general, the results above were consistent with the perspectives we had from anecdotal evidence gathered by informally speaking with students who had either taken the course previously or were struggling to be successful in the course. Further, the results illustrate the disconnect that we see between the recognized importance of review and the motivation to actually regularly review and cognitively structure that process to obtain successful results.

The second part of our project was the development of workshop days to create a group approach to critically thinking about and solving chemistry related problems. For this part, we created five workshops that consisted of preliminary materials to set the stage and direct student preparation by referring students to sections in their textbook, journal articles and other sources of information for each topic. In addition, we created the handouts students were given in class on the workshop day which led them through an analysis process and queried their understanding at numerous levels ranging from rephrasing of concepts in the preliminary materials to the evaluation of techniques or synthesis of a method to solve a presented problem.

As requested, we used the holistic critical ranking form as one method of evaluation. This rating method was applied to the second and fourth (out of 5) workshop day assignments. This particular assessment was completed for 10 randomly selected groups of the 26 groups in the class, and the results are depicted in the graph below, along with additional data to link these results to other measures of student performance.

Holistic Critical Thinking Rating compared with other measures of student performance



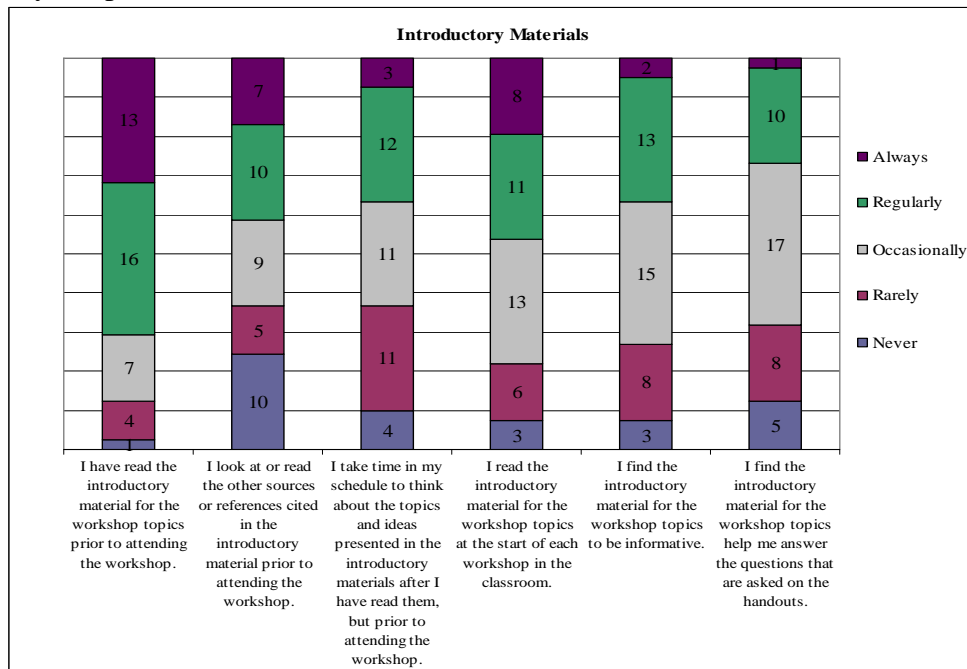
Median Course Overall: Within the students of each group, the median overall score in the course including all assignments, exams, etc.

Workshop Score: The total score on all 5 workshops for each group, based on the instructor-developed grading rubrics, which were tailored to the topic for each workshop.

Within the limits of the data, these results suggest the following:

- Using the Holistic Critical Thinking Rating as the measure, 4 groups improved through the course of the semester, 5 groups remained the same, and only 1 group declined.
- Workshop scores are approximately correlated with the overall performance in the course.
- In a broad sense, the Holistic Critical Thinking Rating, and improvement in this measure over the semester were relatively consistent with the overall workshop score based on our grading.
- Of these randomly selected groups, Group J is notable in that while the median overall score for this group is significantly higher than the others, the workshop score is only the 6th-highest of these 10 groups, and furthermore, Group J is the only one whose Holistic Critical Thinking Rating decreased from Workshop #2 to Workshop #4. Based on one of our observations of this group’s interactions, this is consistent with a broader trend within this course that students quite frequently are motivated more by grades than they are by learning or intellectual challenge. By the time of workshop day #4 (the 11th week of the semester), the students in this group were justifiably confident that they would receive a “good grade” in the course, and as they essentially related to one instructor, they “just didn’t feel like thinking that hard” on that particular day.

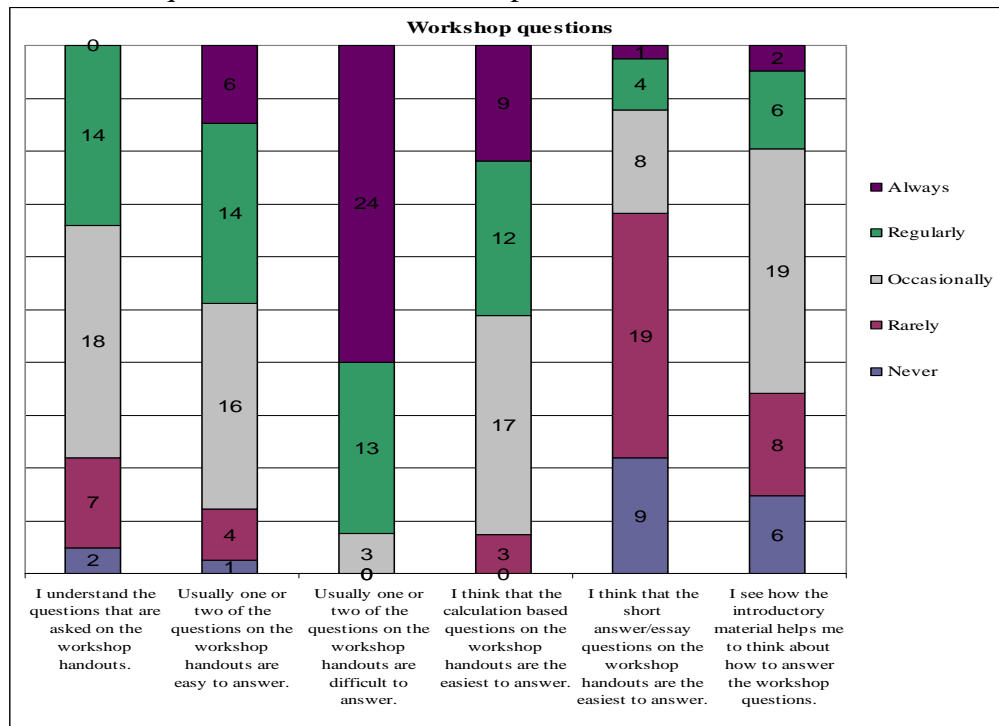
To gain more insight into our student’s perceptions about the workshops we developed a survey tool that we made available to students on D2L. The outcomes to each section of the survey are presented below:



The first part of the survey asked for feedback on the preliminary materials that we designed to “set the stage” and direct student preparation by referring students to sections in their textbook, journal articles and other sources of information for each topic.

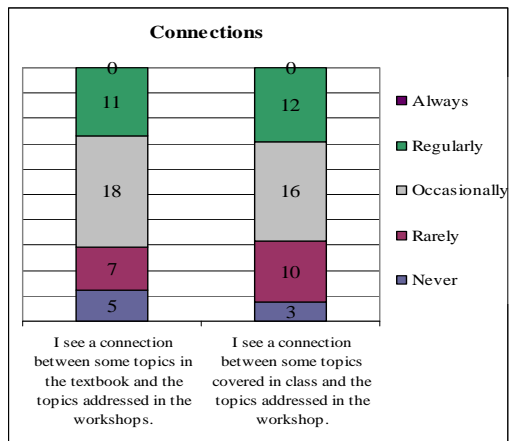
- 41 of the 106 students who finished the course (39%) responded to this survey.

- The majority of respondents (71%) indicated that they regularly read the preliminary materials made available prior to each workshop.
- A minority of respondents (41%) indicated that they read the sections in the textbook or articles referenced in the preliminary materials.
- A minority of respondents (36%) indicated that they made time to think about the topics and ideas prior to each workshop with only 7% indicating that they regularly did so.
- Small numbers, 37% and 27% respectively, of respondents indicated that they found the introductory materials informative or helpful when they worked with their groups to answer the questions for each workshop.



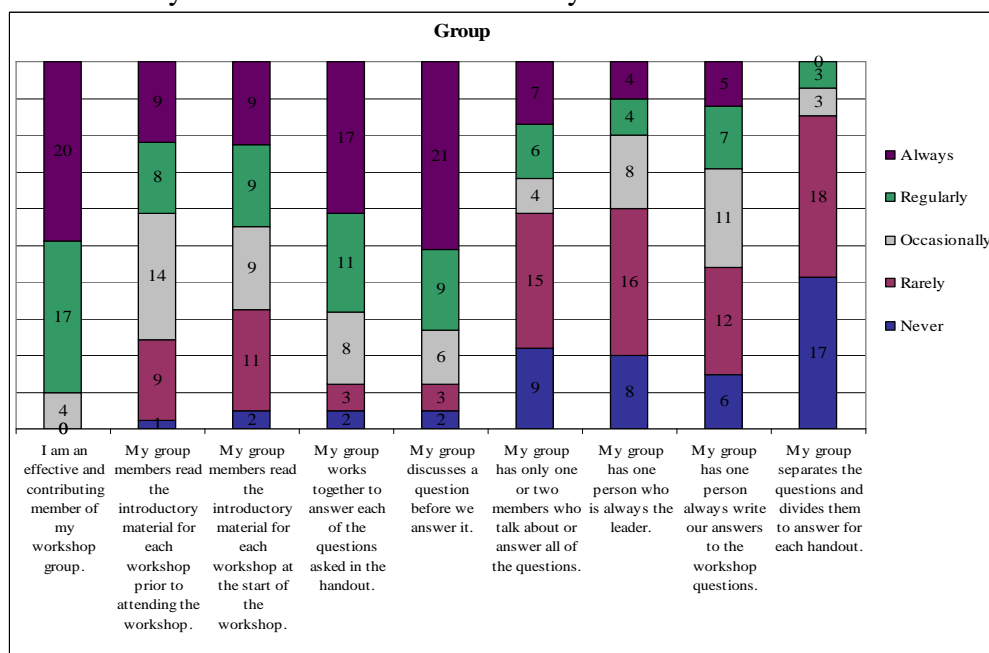
The second part of the survey asked for feedback on the handouts students were given in class on the workshop day which led them through an analysis process and queried their understanding at numerous levels ranging from rephrasing of concepts in the preliminary materials to the evaluation of techniques or synthesis of a method to solve a presented problem.

- No respondents reported always understanding the questions asked on the handouts and a minority (34%) reported regularly understanding the questions. Correspondingly, 5% and 15% reported seeing how the introductory materials helped “set the stage”. This is lower than the percentages from the previous section for statements regarding the relationship between introductory materials and workshop questions.
- A large number (95%) of respondents indicated that one or two of the workshop questions were difficult to answer with most (82%) indicating that short answer essay questions were perceived to be the most difficult.



The third part of the survey sought feedback on our students perceptions of the connections between the workshops and concepts found in the textbook and/or discussed in class.

- No respondents reported always seeing a connection.
- A small number (27%) reported regularly seeing connections. This is consistent with the small number of respondents that reported reading the other sources referred to in the introductory materials section of the survey.



The last section of the survey was designed to generate feedback on how our students' perceived their group members.

- Most respondents (90%) indicated that they perceived themselves to be contributors and effective group members.
- Smaller numbers, 32% and 20% respectively indicated that their groups were dominated by one or two individuals who always talked or took charge.
- No respondents reported that their groups always divided questions and answered them separately and a small number (<1%) reported using that approach regularly.

- The majority of respondents indicated that they perceived a constructive group dynamic including working together (71%) and discussing questions (73 %) prior to answering them.

We found these survey results to be interesting in several ways. First, we consistently observed a significant number of students who actually read the preview materials during the workshops. During many of the workshops approximately a third of the students were quietly reading that material for the first 20 to 30 minutes. This is somewhat consistent with the survey results, but inconsistent with their self-perception of being an “effective” group member. This lack of preparation is also mirrored in missing the connections between the workshop topics and previously presented concepts, the importance of the introductory materials as well as the large number of respondents who reported perceiving the workshop questions to be very difficult to understand and answer. Further, these results also illustrate the disconnect that we see between the recognized importance of preparing for assessment activities and the motivation to actually do so. We also believe that it suggests that our students struggle to acquire their knowledge of chemistry at the lower levels of Bloom’s taxonomy more than we recognized and thus asking them to work in the higher order domains may not be appropriate for the general chemistry sequence.

4. Issues: What issues or challenges arose during project implementation/completion? How were they addressed?

The attempts to stimulate consistent and constructive review of topics from General Chemistry I did not seem particularly effective. The survey results suggest that the students recognize the necessity of reviewing the topics, but the results of the review quizzes and the overall class performance suggest that they do not engage in nearly enough review activities. It is difficult to envision ways to further motivate and structure students’ reviewing activities without detracting from the course content of General Chemistry II. We believe that while our students recognize that reviewing topics from General Chemistry I is crucial to their success in General Chemistry II, they simply do not allot enough time to this activity.

For the workshop days, the primary challenges were centered in two different areas. First, we found that, far more than we had anticipated, students struggled to understand and answer the questions posed in the workshop assignments. While we designed the workshop assignments to be challenging, we also designed them to be consistent with the typical expectations for this course. In answering student questions during the workshop days, it was very clear that many of the students struggled so much with the baseline information that expecting them to think critically at the higher levels of Bloom’s taxonomy was perhaps overly ambitious. We also perceived a disturbing inability for them to understand the questions from a basic reading comprehension/vocabulary perspective. As this became apparent in the earlier workshop days, we tried to make the later workshops more straightforward, but we did not see a significant improvement in the student’s ability to understand the questions without great difficulty.

The other primary challenge involved the effectiveness of the student groups. Based on our observations, approximately 70 % of the groups were “functional” (*i.e.*, students participated freely and seemed to stay on task). Even though we occasionally received second hand reports of complaints about the workshops, for the most part, the atmosphere in the classroom on workshop days was positive, and they seemed to enjoy the chance to work together. There were some groups that did not appear to function as well, and this seemed to revolve around interpersonal communication skills. At various times, we tried to offer suggestions to help these groups work together more effectively, but these attempts were generally unsuccessful. We believed that the percentage of functional groups was reasonable given the wide range of student personalities and motivation levels in this large class.

Despite the fact that our students believed the group dynamics were positive and the general atmosphere was positive, we believe that the groups were not truly effective in completing the workshop assignments. To some extent we attribute this to their fundamental difficulties with the baseline knowledge, but it is also clear through our observations that many students appear deficient in their development of productive group work skills. In many cases, we found that if the students were “prepared” to start the workshop, they spent the first 20 – 30 minutes of the 50 minute class period “talking in circles” and collectively made little progress in understanding much less answering the questions. We attempted to correct this situation in several ways. During the workshops this included actively asking the groups to restate their understanding and then asking leading questions. Prior to the second and subsequent workshops we also placed a greater emphasis on the need for the students to read the preparatory materials beforehand, added leading questions to the preparatory materials and streamlined the workshop assignments to start with more straightforward questions and calculations in an effort to create a more successful on-task start for each group. These attempts were only marginally successful and sometimes resulted in one or two members working on the calculations while others chatted; further it did not seem to change their general level of preparation. As the term progressed, we suspected that students believed the workshops were productive because they enjoyed talking – even talking about chemistry - but not stretching their understanding of it. Thus, we suspect that in General Chemistry I and/or II this teaching technique is more effective for reinforcement of concepts instead of exploration and extension into the hierarchy of Bloom’s taxonomy.

5. Dissemination: How did you (or do you plan to) disseminate your project and/or its results? (e.g., published article, department colloquium, professional conference, meeting, college colloquium, university-wide colloquium, publication, IPESL website).

At the start of the project we envisioned a variety of methods to disseminate our results including presentation at a university colloquium or publication on the IPESL website. At the writing of this report, we are also evaluating the viability of this study for development into a publication targeted for a chemistry education venue such as the online journal “The Chemical Educator”.