# Chem 112 Hybridization Project

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### Introduction

Beginning in 2005, the chemistry department (together with several members of the Center for Learning and Teaching and with the support of the administration) undertook the task of revitalizing Chem 110, the first semester general chemistry course. Prior to 2005, Chem 110 had the highest failure and withdrawal rate of all courses at Penn State Berks. The web-enhanced version of Chem 110 had several components to it, most notably class guides and pre-class assignments to ensure students were prepared before they came to class, scaffolded clicker questions to help guide students’ ability to problem-solve, peer mentors in the classroom to help the students as they encountered difficulties, and post-class quizzes to assess students competency with material. The redesign of Chem 110 was overwhelmingly successful and several publications came from the project (see references below).

Upon completion of the redesign of Chem 110, the chemistry department began to redesign both semesters of Organic Chemistry, Chem 210 and Chem 212. These two courses were also extremely difficult for students although outcomes in the courses started at a much higher level than in Chem 110. It was only after Chem 210 and Chem 212 were successfully web-enhanced that the department realized we had somehow skipped the second semester of general chemistry, Chem 112. This project was begun to redesign Chem 112 so that it was similar in style to Chem 110 although certain aspects (such as peer mentors, basic online quizzes and clicker questions) were already implemented in the course. The hope was that we could mimic the success of the Chem 110 redesign on student outcomes and increase student success in the course. Also, by changing the format of Chem 112 to a format similar to Chem 110, we hoped that the students would already be familiar and comfortable with the layout of the course and would only have to focus on learning course material rather than on the logistics of the course.

### Project Design

1. Create Class Guides that students access on ANGEL prior to the start of class
2. Create PreClass Assignments that assess whether or not students have accessed the Class Guides
3. Modify existing clicker questions so that they scaffold in difficulty throughout the class period
4. Create quizzes to assess students’ competency with material after class

Class Guides were created that are similar in structure and format to the guides currently implemented in Chem 110. These guides contain brief notes and examples as well as indicate important and non-relevant information in the text. Each Class Guide also contains the learning objectives students must be able to successfully complete at the end of each class period. These learning objectives are primarily in the analysis and application levels of Bloom’s Taxonomy, although some are in the knowledge and the evaluation levels.

PreClass Assignments were also created (and are linked at the end of each Class Guide, as they are in Chem 110). The PreClass Assignments are meant to be ‘good faith’, which means that a student does not have to answer the question correctly to receive full credit. However the student has to be giving, in the instructor’s opinion, an honest effort at answering the question. PreClass Assignments are low stakes.

The clicker questions have been modified and updated so that most of them are no longer multiple choice. Students are often adept at identifying and eliminating distractor choices without understanding how to complete the problem. By changing the questions so that students must provide an answer we are better able to determine whether or not students comprehend the material. Peer Mentors help the students as they work through problems, identifying key misconceptions and helping the students work together.

As of this point, a quiz has been created and posted on ANGEL for each chapter of material covered in Chem 112. These quizzes address the learning objectives as noted in the Class Guides and are designed to test students’ understanding of the objectives.

### Learning Outcomes

The students were split into six overall groups, (i) Traditional Fall Students (T-F); (ii) Traditional Spring Students (T-S); (iii) Web-Enhanced Fall Students (We-F); (iv) Web-Enhanced Spring Students (We-S); (v) Traditional Summer Students (T-Su); (vi) Web-Enhanced Summer Students (We-Su). The n value of the T-Su students (34) and We-Su students (45) were small compared to the other four groups so the summer students were excluded from all analyses, leaving four groups total. The cut-off used for traditional versus web-enhanced was the Fall semester of 2009, as the process was begun at that time. In general, Fall students were compared against each other (T-F versus We-F) and Spring students were likewise compared (T-S versus We-S).

The first metric analyzed was the number of attempts and withdrawals each group of students had from the course. The students in the We-F and We-S groups had significantly lower numbers of attempts at Chem 112 and a lower percentage of withdrawals than their counterparts (AS = 0.000 in all cases, Figures 1 and 2). When the groups were further broken down into their respective gender groups, only the spring semester groups had enough students to compare to each other. The T-S group had a higher number of attempts and a higher percentage of withdrawals for both females and males than did the We-S group (AS = 0.000 and 0.007 respectively, Figures 3 and 4).

The second metric analyzed was student outcomes in the course, as reflected by their earned grades in the course. Student grades were converted to the numerical scale that corresponded to their transcript letter grade as per Penn State Policy. Because the possibility exists that students might have taken the course more than once, a variety of grades were analyzed, including students’ first grade in the course, students’ average grades in the course, and students’ highest grade in the course. For high, first, and average grades, the Web-Enhanced students had higher earned grades than did the traditional students (AS=0.000 for all cases). As was the case with the analyses of attempts and withdrawals each group was further broken down by the gender of students. As before, sample size considerations limited the comparison to the T-S and We-S groups. In the traditional format, males earned significantly higher grades than did females, but this switched in the web-enhanced format with the females earning higher scores (AS = 0.000). For males and females, however, the web-enhanced students out-earned their traditional counterparts (AS = 0.000, Figures 5 and 6).

**Figure 1:** Number of attempts by groups of students (T-F = Traditional Fall Students; We-F = Web-Enhanced Fall Students; T-S = Traditional Spring Students; We-S = Web-Enhanced Spring Students, AS = 0.000)

**Figure 2:** Fraction of withdrawals by groups of students (T-F = Traditional Fall Students; We-F = Web-Enhanced Fall Students; T-S = Traditional Spring Students; We-S = Web-Enhanced Spring Students, AS = 0.000)

**Figure 3:** Number of attempts by groups of students and by students’ gender (T-F = Traditional Fall Students; We-F = Web-Enhanced Fall Students; T-S = Traditional Spring Students; We-S = Web-Enhanced Spring Students, AS = 0.000)

**Figure 4:** Fraction of withdrawals by groups of students and by students’ gender (T-F = Traditional Fall Students; We-F = Web-Enhanced Fall Students; T-S = Traditional Spring Students; We-S = Web-Enhanced Spring Students, AS = 0.000)

**Figure 5:** High grades, average grades, and first grades by group (T-F = Traditional Fall Students; We-F = Web-Enhanced Fall Students; T-S = Traditional Spring Students; We-S = Web-Enhanced Spring Students, AS = 0.000)

**Figure 6:** High grades, average grades, and first grades by group and students’ gender (T-F = Traditional Fall Students; We-F = Web-Enhanced Fall Students; T-S = Traditional Spring Students; We-S = Web-Enhanced Spring Students, AS = 0.000)

### Discussion and Future Plans

Overall, the initial outcomes of the course are positive. Although the web-enhanced course needs to run several more semesters in order to acquire enough data for strong comparisons, the students in the web-enhanced sections appear to out-perform their traditional counterparts. For example, both fall and spring traditional students had an average of 1.5 attempts at the course, the web-enhanced fall students had an average of 1.2 attempts and the spring web-enhanced students had an average of 1.1 attempts. As the redesign has decreased the number of attempts, there has been a corresponding decrease in the number of withdrawals in the course. Although the fall web-enhanced and traditional students have the same fraction of withdrawals (0.07), there has been a significant decrease in the web-enhanced spring students from the traditional fall students (0.26 decreased to 0.11). Generally, the spring students are the students who entered Penn State and were determined ‘ready’ for general chemistry and enrolled in Chem 110 in the fall, and Chem 112 in the subsequent spring semester. The fall students are generally ‘under-prepared’ and required remediation in math, chemistry, or both before enrolling in Chem 110. Web-enhancing the course has significantly helped those students determined ready for general chemistry.

Student earned grades are also significantly better in the web-enhanced course than in the traditional course. All types of grades analyzed (high, average and first) were significantly higher for the web-enhanced students than the traditional students (C to C+ for high, C to C+ for average, and D to C+ for first grade for the Spring students; and C to B- for high, C to C+ for average, and D to C+ for first grade for the Fall students). The first grade earned by students in the traditional versus the web-enhanced course is of particular interest. In general, students in the traditional format were earning an average grade below passing their first time through the course while the web-enhanced students were earning a C+ to a B- their first time through the course. This is extremely promising for the course redesign.

The switch in high grades, average grades, and first grades by gender is also extremely interesting. In the traditional format, males out-performed females significantly in all categories of grades. However, in the web-enhanced format, females out-performed males significantly in all categories. These are promising results for females, traditionally under-represented in the physical sciences at Penn State Berks. Of particular interest is the first grade earned by females in the traditional format versus the web-enhanced format. The traditional females earned an average grade of 1.80 (D), while the web-enhanced female students earned an average grade of 2.48 (C+). Males also saw an increased first grade from 1.83 (D) to 2.43 (C+) from traditional to web-enhanced.

There is still much work to be done to complete the transition to a web-enhanced Chem 112 course. For example, we are planning to expand the number of quizzes from eight (one per chapter) to eleven (one per week). The increased number of quizzes will match the format of Chem 110 to which the students are accustomed and will give us the opportunity for further testing their understanding. The clicker questions, although excellent for a first draft, need some modifications as we have learned what drove towards our learning objectives and what distracted from them. We have planned on modifying the clicker questions and the quizzes during the summer session of 2013 and plan on implementing them by the Fall semester of 2013.

We would also like to expand the information in the class guides to allow for short videos and worked out problems where the students can hear as well as see what we are doing. We hope to make short videos using software such as Camtasia to record and Doceri to allow us to write on our PowerPoint slides. Although we plan on beginning these during the summer of 2013, we do not expect them to be fully implemented until the Fall semester of 2014.

### Scholarly Outcomes

This work has been accepted for presentation at the Gordon Conference for Chemistry Education, Research and Practice, June 9 – 14, 2013, Salve Regina College. “Web-Enhanced General Chemistry II”, Katie E. Amaral. It is our hope that this presentation will lead to a scholarly article in the *Journal of Chemical Education*.

### Conclusions

Overall, the web-enhanced version of Chem 112 has promising results, with increased earned grades and decreases in attempts and withdrawals. It is our hope that as the web-enhanced version of the course is tweaked, the student outcomes will remain positive and Penn State Berks students will benefit from the changes.

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