CHEM 131-132 Course Redesign Report 2016

1. *Project motivation and goals:* A brief explanation of the motivation of the redesign project and the goals that were established at the outset (along with any modification of goals that were developed during the year)

In the previous efforts in course redesigns, we have successfully transformed the general chemistry sequence, CHEM 121 and 122, into active learning classes. Data showed that student performance in these redesigned courses was significantly improved, indicated by concept gains and improvements in comprehensive final exams. However, the reform of our general chemistry curriculum cannot be completed without considering the particular group of students who are pursuing STEM related fields that require more in-depth and knowledge of chemistry to lay a good foundation for them to take advanced science and engineering courses. These students were usually the high achieving students in CHEM 121 and 122, who have not been the target by the previous redesign efforts. This project was therefore a separate effort to reform our previously known as the "honors general chemistry" sequence, CHEM 131 and 132, and to streamline the placement of students between CHEM 121/122 and CHEM 131/132 sequences. We expect the outcomes of this project will

1. provide relevant, "in context" learning to students in STEM-related fields,
2. promote student interest and skills in the application and research of chemistry and therefore improve STEM retention,
3. Establish a data-driven placement system for CHEM 121, 122, 131, and 132

This project also has the longitudinal goal to

4. Improve student performance in the subsequent STEM courses that use chemistry knowledge learned from CHEM 131/132.

The context-based, modular approach we have developed has known positive effects on student learning. First, the use of real-world questions gives students why we study chemistry, and renew their interest in pursuing STEM fields. This is an important step to reverse the existing trend that students lose interest in the subject after finishing the foundational chemistry course because of the irrelevancy of the course materials to their personal and professional interest. Secondly, our context-based approach will provide students with practical examples of the applications and practices in the advanced courses and future career. Existing models with a similar philosophy such as Wright State

University math pre-requisite course have demonstrated the effectiveness of this approach. Furthermore, establishing an effective placement to students taking an appropriate general chemistry course would help each course to focus on students and enable instructors to bring more effective learning strategies to students. As the results, we expect that the benefits of this project are not limited to CHEM 131 and 132, but extended to the former redesign courses of CHEM 121 and 122. We believe not only the recruitment and retention of chemical related majors will be improved, but also the performance of other students in CHEM 121 and 122 will be increased. The long-term effect to other courses is a subject for further investigation but with a positive prospective.

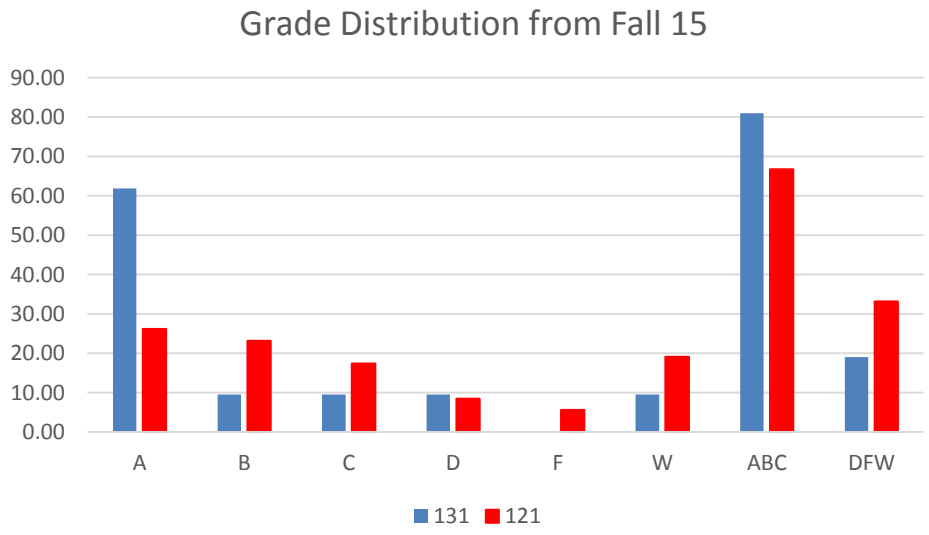
2. *Project summary:* Summarize the instructional redesign components (this will likely come from the proposal along with modifications that may have been made)

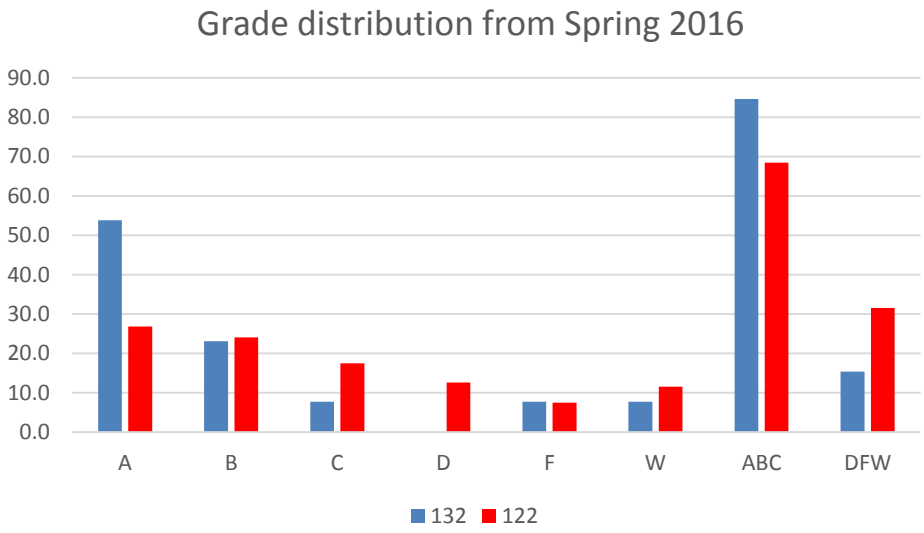
- Established course learning outcomes that align with HED competencies and STEM major requirements. This was done in the summer of 2015 for both CHEM 131 and 132.
- Developed similar class structure as the redesigned CHEM 121/122 to help students make an easier transition if they decide to switch between the 121-122 and 131-132 sequences. This class structure includes pre-class reading assignment, in-class discussions, and the use of ALEKS for pre and post-class exercises. What CHEM 131/132 have but not in CHEM 121/122 are synthetic questions (SQ) which are described below. All pre-, in- and post-class activities are collected in each teachable unit called "Module".
- Developed structured pre-class reading assignments and formative assessments using ALEKS to enable students and instructors to monitor acquisition of basic facts and concepts before class;
- Created in-class, research focus exercises and questions which require higher-level thinking with optional follow-up references. These are combined with clicker questions that test these higher levels of thinking for assessment in the large classes. This was done in the summer of 2015 for 131 and during the winter break of 2015/2016 for CHEM 132.
- Created SQs designed to raise the student's BLOOM level by synthesizing the knowledge acquired in the module. The SQs require extensive research of the topics related to each module, and thus time consuming. This was done in the summer of 2015 for 131 and Winter break between 2015 and 2016 for 132.
- Administered the same modified chemistry concept inventory tests (CI) given to CHEM 121 and 122 students to CHEM 131 and 132 students to compare student concept learning between the 121/122 and 131/132 sequences. These CI tests were given in the Fall 2015 for CHEM 131 and Spring 2016 for CHEM 132. The pre-test was implemented during the first week of each semester and the post-test during the week 16 of each semester. Data generated from all assessments mentioned were analyzed and discussed – see the conclusions in the assessment section.

- The revisions were undergone for CHEM 131 and 132 during the summer of 2016 to implement for the 2016-2017 academic year.
- The placement system using ALEKS was piloted in the summer of 2016. If the data collected during the pilot implementation show evidence of the effectiveness of placing students in either CHEM 121 or 131 courses, the new ALEKS placement system will replace the current pre-requisite requirements for CHEM 121/122 and CHEM 131/132.
- The introduction of research-active faculty members in the teaching team has provided a motivational factor and practical opportunities for students to be exposed to research. The following researchers have helped to teach the course in 2015-2016 academic year: Drs. Bernie Hernandez (Sandia Labs), Abhaya Datye (Chemical Engineering), Rick Kemp (Chemistry), Lorraine Deck (Chemistry), Yang Qin (Chemistry), Jaime Stearns (Air Force Research Lab), Al Viggiano (Air Force Research Lab), Dave Whitten (Bioengineering).

3. *Assessment:* Present any and all data obtained as part of the originally stated or modified assessment plan that are related to students' (a) learning (e.g., outcomes assessment data, pre/post-test or concept-inventory results), (b) success (e.g., grades), and/or (c) attitudes (e.g., surveys). These data should be briefly interpreted.

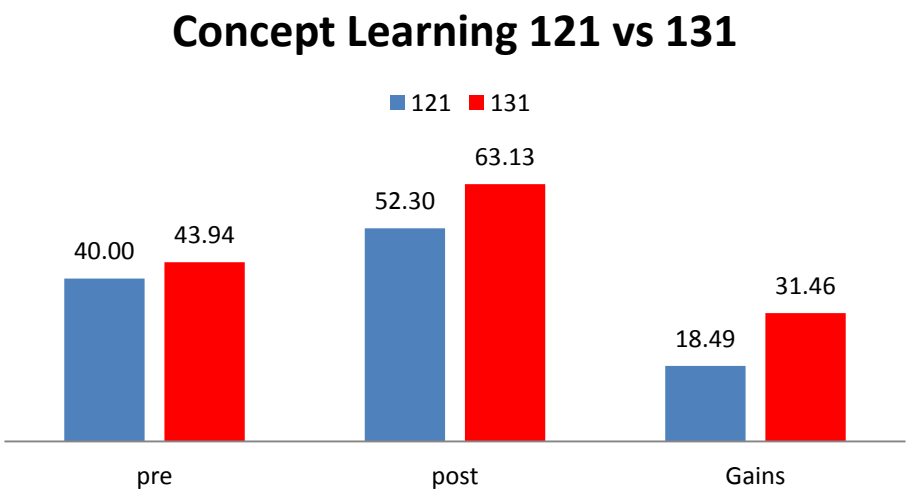
A. Passing rate of CHEM 131/132 vs 121/122

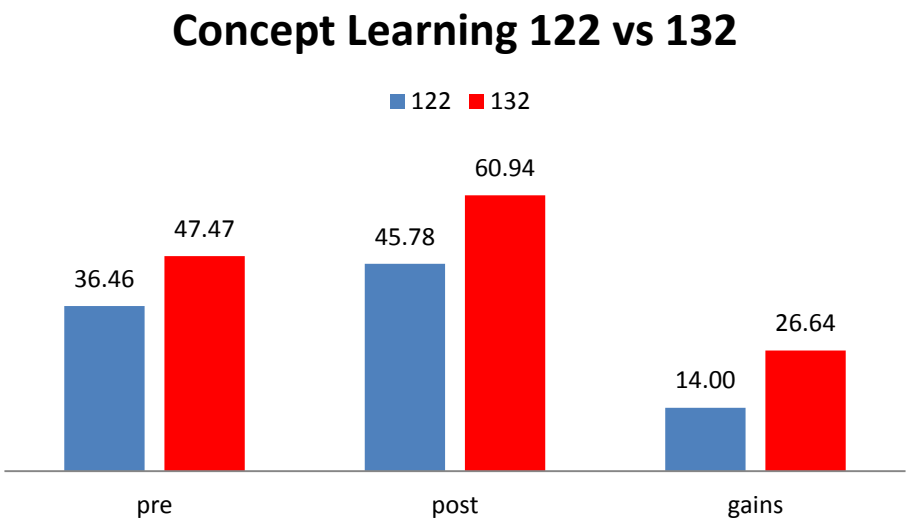




From both semesters, the CHEM 131/132 classes showed better passing rate (ABC) than CHEM 121/122 classes by more than 10%. It is a significant performance difference. The better passing rate from CHEM 131/132 is not a result of easy requirements since the general perception from the students about CHEM 131/132 is they are difficult courses with more in-depthcontent than CHEM 121/122. In addition to effective teaching strategies, student's motivation and better academic skills are believed to be important factors for CHEM 131/132 students.

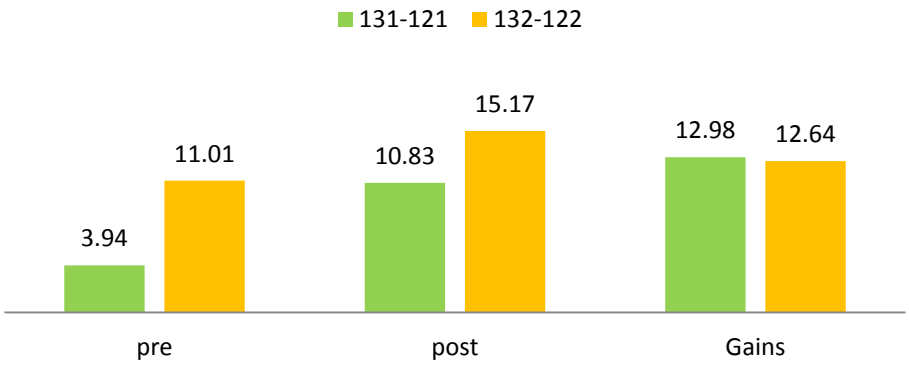
B. Concept Gains of CHEM 131/132 vs 121/122





From the two Figures above, the CHEM 131 and CHEM 121 students had similar level of preconception in the pre-test, but CHEM 131 students significantly outperformed CHEM 121 in the post-test, thus greater concept gains from the semester. In the subsequent semester, CHEM 132 students showed superior preconception, post-test mean, and concept gains.

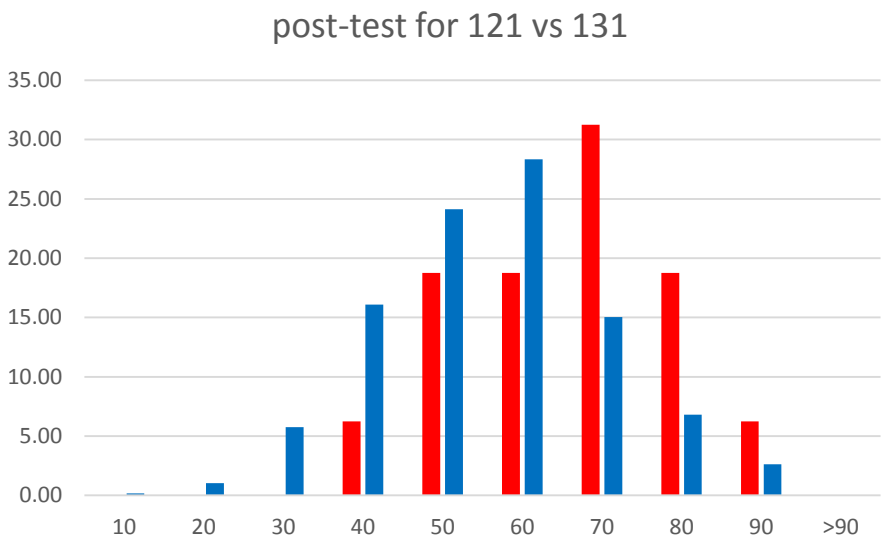
To help exploring further in the difference of the concept learning between the two courses, another graph was made for the differences between each test and concept gains, as shown in the next figure.

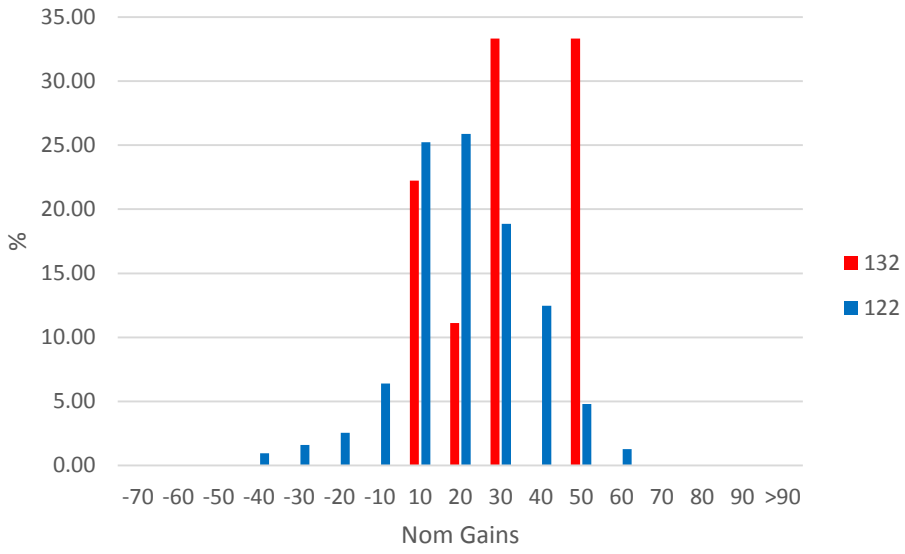


This figure shows that the 121 and 131 students have the same level of preconception when entering the semester, indicated by the small difference of the pre-test means (3.94) calculated as (mean of 131 – mean of 121). The higher requirement of ACT or SAT Math for CHEM 131 students does not demonstrate better pre-class chemistry concept from this figure. The small difference between the two courses was widened in the post-test (10.83), indicating greater concept gains from CHEM 131 students than CHEM 121 students (a difference of

12.98). After the winter break, this difference was maintained as shown in the pre-test of the spring semester (11.01 vs 10.83) which is evidence of a good correlation between the two concept inventories.

The concept gain difference between the two courses became even greater on the post-test by the end of spring semester (15.17). Compensated by the high pre-test difference, the difference of the overall concept gains is about the same as the previous semester from 131/121, i.e., even the difference of post-test is larger, the difference of gains between the two courses remains the same (12.98 vs 12.64). This indicates the CHEM 132 also provides more effective student concept learning than CHEM 122.





C. Attitude differences

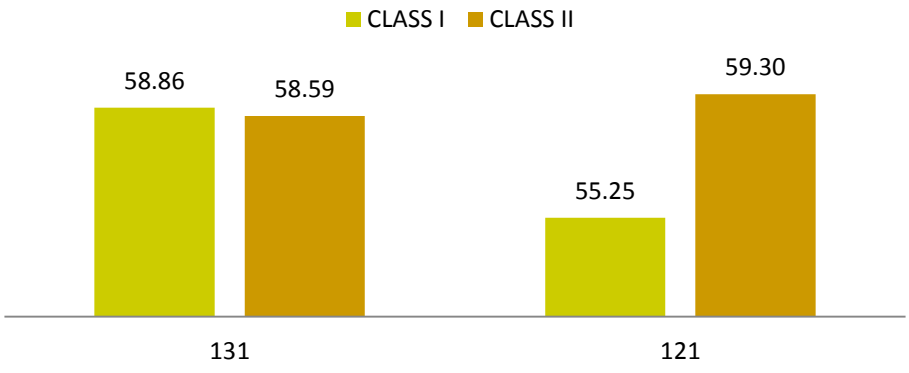
Student Attitude changes were studied by using pre- and post-CLASS during the fall semester of 2015 and the spring semester of 2016. The following two figures are the means from pre- and post-CLASS of CHEM 121/131 and 132/122. The main features of these graphs are summarized below.

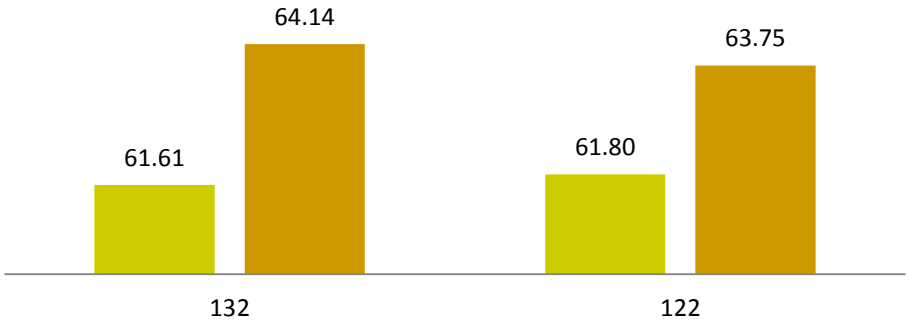
a. *The attitude scores from the spring semester are higher than the fall semester for both courses. The reason for this trend is unknown.*

b. *The CHEM 131 students decreased their attitude after the semester, but the decrease is insignificant. In contrast, CHEM 121 students showed a dramatic increase of attitude after the semester is finished, which is a consistent trend from CHEM 121 and 122 since the course redesign in 2012 and 2013.*

c. *The CHEM 132 students showed a significant increase of attitude after the semester is finished, a consistent trend with CHEM 122 students.*

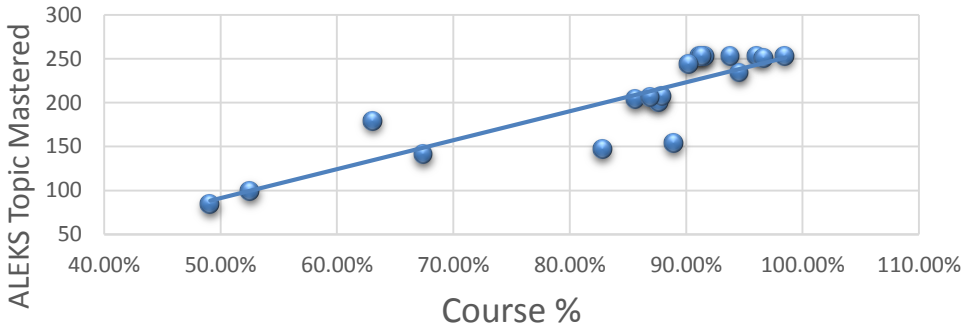
There are many possible factors for this difference of attitude change. One factor is not related to how these courses were taught. The CLASS was administered in the lab. The pre-CLASS (CLASS I) is required for student for lab check-in. The post-CLASS (CLASS II) is optional with an incentive to drop their lowest grade of the pre-lab reports. Therefore, more low achieving students who need the incentive took CLASS II. The results might be bias toward low achieving students.





D. *Effect of ALEKS exercises*

The figure below shows the correlation between ALEKS topic master and student final grades. A strong linear correlation is shown from the study. This strong correlation supports the implementation of ALEKS exercises in these courses.



E. Surveys from students

From CHEM 131

1. The major reasons other than it is a required course students took CHEM 131 over 121 are
   (1) you think you will need chemistry for your future courses (13/15)
   (2) you think you will use chemistry in your career (14/15)
2. Most students expected a class to be harder and more in-depth than 121, and faster in pace.
   They thought the course will be like AP Chemistry or a general chemistry which covers basic chemistry knowledge to prepare them for further chemistry courses.
3. Most students studies for the course three days a week when there were scheduled classes. The most selected study methods from the surveys are reading textbook and practice ALEKS, and they usually study alone.
4. When students encountered questions, they were more comfortable asking other students about their questions than coming to instructor's office hours. It is very common for these students to google the questions.
5. This course was not considered the most difficult one among other science courses students took, but the second most difficult one.

6. Students considered ALEKS and exams are the main reasons this course is difficult. Both selections assessed students' learning and required students to retrieve information they have engaged in before and during the class time, and therefore helps students to make the transfer from short term to long term memory.
7. The two most selected strategies students think that cause learning are
   (1) Reading the textbook (15/15) and (2) practicing ALEKS (12/15)
8. The two most selected characteristics about LAEKS students chose are (1) It helps me learn the course material. (12/15) and (2) It is really time consuming. (14/15)

From CHEM 132

1. *Most students chose reading textbook as the most useful method of study for the course. This method stays as the most popular choice of study from both 131 and 132. We are encouraged over this result because it has been a known problem among college students that they seldom read textbooks.*
2. *The ranking of ALEKS for effective study tool from 132 students dropped, but remained the fourth most effective methods. Even though students do not like it, but they recognized ALEKS being an effective tool for learning.*
3. *Most students do not consider Synthetic Questions (SQ) as an effective learning tool. It is understandable because SQ usually required solid understanding of the topics and higher levels of Bloom's taxonomy. It could be very time consuming.*
4. *The students' view of lecture is mixed. The ranking ranged from the 1st to the last. With small sample size, the result is non-conclusive.*

4. *Improvement:* Provide a summary of the curricular and pedagogical changes you are planning to make in light of the collected assessment data and your teaching experiences.

- ALEKS

  ALEKS remains in the top four list for effective studying tools. Most students recognize it as effective for their learning of the course materials and preparation for the exams, even though they also felt it is very time consuming and do not like it. We will reconsider the time and coverage of the current ALEKS setting to reduce the burden of students, and streamline the questions to be more focus on the key topics we want students to learn.

- SQ

  The student responses for SQ was mixed, partly because our inexperience in making these comprehensive questions. We plan to reexamine all SQs to make sure that the content is sufficiently relevant to the materials in the module and sufficiently advanced to help the student to go beyond the course work.

- New ALEKS placement system

  The past student performance data in CHEM 121 showed the current pre-requisites using ACT or SAT MATH scores are not effective predictors of student success in these courses, and provided incomplete picture to both students and instructors about students' readiness for the

courses. Student readiness for general chemistry cannot be judged by their math and chemistry knowledge alone. There is a large portion of student's preparation that comes from motivation. We have seen many cases where students with weak academic background but with very strong motivation to do well in CHEM 121 did receive high passing grades from the course. We found students with strong motivation would take any opportunities to increase their chance to success in the course and earn better grade. Unfortunately, most placement tests only assess on student's knowledge level of the subject, and provide no information about student's motivation. These high stake exams favor students with high academic background, and are disadvantageous to students with a weaker background but with a strong motivation. From our past experience of using ALEKS system, we saw the possibility ALEKS could reveal student motivation from the placement process. We therefore, develop a placement system using ALEKS for our CHEM 121 and 131 students.

In this ALEKS placement, we use the initial check to assess student's chemistry and math knowledge, and allow weaker students to use up to three weeks to make up their deficiency. After the practice, students can take the final assessments to prove their mastering level of the subject has reached the required level for the course. All activities in ALEKS are available online and can be taken without coming to campus, therefore, no cost for administrating the placement. This process also prepare students for good time management which is a very important metacognitive training.

We are piloting the ALEKS placement in the summer of 2016. Under this placement system, all students are required to take the placement in order to register for 121 or 131. Students are placed into CHEM 121 or CHEM 131 based on their placement scores. We expect a better placement and recruitment of students in CHEM 131 through the new placement system.

5. *Expansion:* Outline your plan for continuation of the redesign project, which should include (a) an indication of the approximate number of sections of the course that will be taught using the redesign in Fall 2016 and Spring 2017 and (b) who the likely instructors will be and/or how those instructors will be recruited. If, compared to Spring 2016, there will be no increase, or there is a decrease, in the number of sections taught with the redesign, then please provide a rationale.

Dr. Guo will continue teaching the redesigned CHEM 131/132 in 2016-2017, assisted by Nicholas Keyes and Dr. Diana Habel-Rodrigues. The registration is already increased to near the full capacity of 40 students. No expansion is planned for the coming academic year. We will focus on refinement of the modules.

6. *Sustaining*: A plan for sustaining the curricular and pedagogical innovations of the redesign. This section should include (a) achievements and/or intentions for accessible curation and dissemination of redesigned instructional components, (b) plans for continued work by the team to assess outcomes and make adjustments for continuous improvement, and (c) plans for assuring successful, self-efficacious implementation of the redesigned course elements by instructors who were not part of the original team.

- We have found the faculty weekly meeting to be very effective for sustaining practice of the reform effort, as well as supporting guest instructors who are new to the style of teaching. At these meetings, instructors set exam questions, discuss assessment results and troubleshoot issues together that individual instructor's face. We will continue this practice indefinitely.
- Conference presentations. We have presented our project in Success in the Classroom, New Mexico Higher Education Assessment & Retention conference, NSF Analytical Chemistry Active Learning workshop, and will present in Biennial Conference of Chemical Education in August.
- A Departmental Website will be created in the future to host reform material for New Mexico higher education communities and provide social network for faculty who wants to adopt the practice.
- We will work with Department's Chair to recruit more faculty and guest speakers to teach CHEM 131/132 in the coming years.