TRANSFORMING CHEMISTRY THROUGH COLLABORATION AND COMMUNITY

PROJECT OVERVIEW

Introductory general chemistry is the fundamental gateway course into the chemistry and biochemistry majors and an essential lead-in to many other STEM disciplines. Despite widespread recognition of problems with the culture, content and pedagogy in general chemistry, course reform is slow and lags behind other STEM disciplines.[1,2] Issues with curriculum and structure often have a negative impact on retention, interest in the subject matter, and attitude about chemistry.[3] This is a particularly pertinent problem at CU. In April 2013 the Office of Planning, Budget, and Analysis at CU released a report titled "Major Fidelity Among New Freshman". This report found that of freshman students entering with a Chemistry or Biochemistry major, only 38% and 50% (respectively) retained that major after two years, compared to an average of 67% across all majors. Chemistry had the lowest retention of any major across all STEM departments, and the second-lowest retention across all majors with more than 10 students. Moreover, there is substantial loss even within the first year. Historically, first-year majors have taken the CHEM 1251/CHEM 1271 sequence of General Chemistry for Majors 1 & 2. Retention and success in this course sequence is poor – over the past five academic years, only 59% of those who begin CHEM 1251 go on to finish CHEM 1271 with a C- or better. Just as disheartening is the data from the Colorado Learning Attitudes about Science Survey (CLASS-Chem)[4], administered to the Spring 2015 CHEM 1271 class, which shows that only 50% of students hold favorable views about conceptual learning in chemistry at the end of the course. **The goal of this proposal is to address this crisis of culture using explicit strategies to promote a sense of community and identity as a science major in a new introductory chemistry course for chemistry and biochemistry majors (CHEM 1400, Foundations of Chemistry).** We hypothesize that building community and cultivating identity will decrease D-F-W rates in introductory chemistry, increase retention rates within the major, enhance success in subsequent chemistry courses, and increase engagement of students in undergraduate research.

CHEM 1400 is a new first-semester course that replaces the current CHEM 1251 course. CHEM 1400 will serve 120 freshman chemistry and biochemistry majors beginning Fall 2016. The primary goals of this new course will be to: 1) improve critical thinking, analytical reasoning and training in scientific process skills, 2) emphasize the big ideas in chemistry in an effort to deepen students' understanding of the core concepts in general chemistry, 3) foster a sense of community and help students develop an identity as a chemistry and/or biochemistry major. This proposal addresses these goals, with special emphasis on the third goal by 1) promoting a student-centered active learning collaborative environment in the classroom, 2) creating a semester-long research project that culminates in student poster presentations, 3) emphasizing diverse career paths of chemistry majors, and 4) developing vertical relationships between first year students and scientists at more advanced career stages.

BACKGROUND

Collaborative Learning and Retention

Retention within STEM disciplines is a major problem, and is particularly alarming in chemistry.[5] As a required course for other STEM disciplines, low retention in chemistry courses affects many departments. Of additional concern, retention of women and underrepresented populations is disproportionately low.[6] Here at CU, 43% of chemistry and biochemistry freshman in 2012 were women, compared to 32% of juniors in 2014. The decrease is largest in chemistry, from 39% to 13%.

Our approach of fostering community and using cooperative learning is grounded in research showing improved outcomes in retention, learning, and research participation. Small groups in class provide a venue for students to interact regularly and form connections with their peers. A sense of connectedness and community is an important factor in STEM retention.[6] As noted in "What Matters in College", relationships with faculty and peers have a strong effect on students.[7] One approach is to develop a learning community for students. This community could take many forms, such as a study group, but as Graham et al. note, "students from groups typically underrepresented in science are less likely to form study groups, may be unaware of the academic benefits of group work outside of class, and confront unintentional biases that may make it challenging to break into established cliques."[8] It is thus critical to pay attention to the intelligent formation of groups, and work to make sure all students experience the same opportunities for collaboration and success.

These interventions can also have a positive impact on learning. Improved learning outcomes through the use of cooperative and active learning are well documented in the literature (e.g. Kyndt et al.[9] and Springer et al.[10] for cooperative learning, Freeman et al.[11] for active learning.) Specifically in chemistry, a recent meta-analysis has shown a positive association between student achievement and cooperative learning.[12] With respect to group formation, Cooper et al. classified students into three levels based on a test of reasoning ability, and found learning effects for pairs of students of differing levels, with students of the lowest level showing the largest potential for gain.[13] We can leverage these findings to help increase learning gains for students who can benefit most. Currently, general chemistry courses use recitations, which have been shown to improve outcomes,[14] but there is room to enrich the lecture component of the course by incorporating substantial cooperative learning, and transform the culture of the course through an emphasis on community.

The SCALE-UP approach developed at NC State University is a successful reform with many similarities to our proposed changes. Students sit at round tables of about 10 students while the instructor roams the room, working collaboratively on "tangibles" and "ponderables." In our model students will also sit at round tables and work collaboratively during class on activities, case studies, and simulations. In the SCALE-UP model measurable improvements have been found in conceptual understanding, course retention, and major enrollment.[15]

Community and Professionalization

As a prerequisite for more advanced courses, General Chemistry provides a foundational overview of the field. Given that we are teaching a course for the majors, we have an opportunity to provide career and community information specific to the practice of chemistry, something that is not offered in any of our other courses. Many chemistry departments offer a professionalization seminar or course that addresses careers in chemistry, with demonstrable improvements in student knowledge of career option.[16,17] Though freshman students also benefit from professional and career information, they are not currently receiving it.[18]

One impact of early professionalization is on student research. Developing strong relationships with mentors and carrying out independent research have been shown to improve outcomes and retention for undergraduates,[19,20] but few chemistry and biochemistry majors currently perform research. For example, in 2013-2014 only 6% of Chemistry graduates carried out an undergraduate Honors thesis, compared to 11% in Physics and 10% in MCDB. Additionally, since 2010-2011, an average of 3.7% of chemistry and biochemistry majors are enrolled in research credits, compared to 9.8% in physics. Undergraduate research benefits all students, not just those who go on to graduate school.[21] Prior work has found that a first-year chemistry course community had a substantial impact on the number of students enrolling in research credits in both their second and fourth year at a large research-intensive university.[22] One key mediator of gains from research experiences is length of the experience[23] – so it is important to introduce students to opportunities early. By creating a supportive community, introducing explicit connections to research in both the lecture and lab, and providing opportunities to learn about research being performed both on-campus and in a variety of careers, we expect to improve the percentage of students who do undergraduate research.

Finally, the Chemistry Club can be leveraged as an avenue to engage students. It has been shown that regular events connecting first-years with more advanced students can increase both club membership and the number of majors.[24] Engaging first-year students with Chem Club has the benefit of connecting first-years with more advanced students, helping them join a larger chemistry community. This benefit is not limited to undergraduate integration – there are also benefits to encouraging better connections with graduate students.[25] Locally, CU-Prime is a Physics student group with similar goals to ours, including community building with seminars, a one-credit class with culminating poster session, and mentorship to students. Their accomplishments can serve as a model for successful reform at CU.

METHODS

The goal of this project is to transform the culture and learning environment in an introductory general chemistry course in order to create a sense of community, help students develop an identity as a science major (and in particular as a chemistry and/or biochemistry major), and foster a sense of personal connection to the subject. To accomplish these goals, we propose to do the following: 1) generate a series of student-centered collaborative activities that will be implemented in the classroom, 2) develop a semester-long research project that culminates in student poster presentations, 3) explicitly emphasize diverse career paths of chemistry and biochemistry majors throughout the semester, and 4) create opportunities for building vertical relationships (e.g. first-year students with LAs, graduate students, Chem Club, postdocs and Professors). Each of these interventions is detailed below.

(1) Student-centered collaborative activities

We will create a series of collaborative activities to promote active learning, engagement in the classroom, peer teaching and learning. These activities will be intentionally designed to provide students with opportunities to deepen their understanding of core concepts, cultivate "higher" cognitive skills (applying, analyzing, synthesizing concepts, thinking critically), as well as make predictions and test assumptions. An example of such an activity might be to have students make predictions about a chemical concept, then use simulations from PhET or the Concord Consortium to test their predictions and build understanding by working through structured questions. This approach is similar to the SCALE-UP model at NC State where student groups are given interesting problems and the Professor, TAs and LAs move around the classroom providing feedback and guidance. Groups will be explicitly structured. The free CATME Team-Maker software can intelligently group students based on instructor provided criteria.[26] Considerations include grouping students with similar project interests, ensuring groups consist of diverse academic backgrounds, and preventing women or minorities from being outnumbered in a group, factors that have been recognized as important in SCALE-UP.[27] The activities themselves will also be structured to explicitly encourage cooperation both within and between groups.

(2) Semester-long research project culminating in a poster presentation.

All students will engage in a semester-long research project and publicly present their results at an end-of-semester poster session. Students will be assigned to groups of 3 or 4, according to their interests, and will be encouraged to select a research area from a list provided. At least three recitation periods will be used to provide: context for the projects, explicit guidance on how to carry out a research project, education on how to identify appropriate resources and references, training in how to create an effective poster, and training on how to carry out peer evaluation.

We will develop a list of research areas with three types of projects: (1) research on contemporary chemistry, i.e. real world problems that require chemistry to solve (For example: what strategies are being proposed for capturing CO_2 and sequestering it?); (2) diverse chemistry careers (For example: attend talk by Dr. Julie Gerberding (Tuesday, October 18 2016). Dr. Gerberding was the first woman to be appointed Director of the Centers for Disease Control, is an accomplished physician and researcher, a consultant to several international health organizations, and now the executive vice president for strategic communications at Merck. Students would then investigate how chemistry might have been essential to her career path, learning more about what the CDC does); (3) learn about local scientific research and/or researchers (For example: read an article or attend a talk by a local scientist and develop a project that explains how chemistry is essential to the research). We intend to provide a list of at least 30 research topics (10 in each category) in order provide guidance and structure to the activity. More than one group will be allowed to select a particular research topic. Student groups will also be permitted to brainstorm their own idea, in consultation with Palmer or Hunter.

Students will have an opportunity to present their work in a culminating poster session that is intended to give them practice communicating science and research results in a mode that is authentic to the discipline, build community as they showcase their work, and promote peer evaluation, again a skill that is essential to the discipline and possesses educational value.[28,29] Currently chemistry majors have limited opportunities for giving presentations. We anticipate a total of 30-40 posters (120 students in groups of 3 or 4). Other students, faculty, and staff from any department will be invited and welcome to attend. Each student will stand by his or her poster for 15 min, while the remaining students will roam the room, viewing and evaluating assigned posters. Students will then rotate positions, so that each student has the opportunity to present the poster individually.

(3) Emphasizing diverse career paths

The course curriculum will be organized around "big ideas" in chemistry and at the introduction of each unit, we will create a "Careers: Chemistry in Context" lead-in emphasizing the application of the concepts within a unit as well as career paths that depend on the concept. We will strive to highlight diverse career paths as well as present examples from historically underrepresented populations in the sciences, such as a women and minorities, throughout the course. The contributions of women and minorities to chemistry is often overlooked in the brief history of chemistry found in textbooks, so we will enrich the course with examples of successful chemists from all backgrounds.

(4) Vertical relationships

In addition to efforts aimed at enriching peer interactions, we strive to break down barriers between first year majors and scientists who are more advanced in their education, training, and career, including more senior undergraduates, graduate students, postdocs and professors. The classroom will be the first avenue for promoting interaction between students and the Professor (Palmer or Parson), Research associate (Hunter), and the 4 TAs and 4 LAs who will attend class and facilitate collaborative learning activities during each class period. Secondly, we will coordinate with the Chem Club to host activities such as demo night, liquid-nitrogen ice cream, and a career panel targeted at getting the first-year students involved. Finally, we will host a science "speed dating" session in which undergraduates will have the opportunity to attend a ~ 1 hour event with graduate students and postdocs from the Department. Participating graduate students and postdocs will be carefully chosen and trained on effective science communication and will be asked to prepare a 5-10 minute general overview of their research. We anticipate running two sessions in which 8-10 graduate students or postdocs will present to small groups (~ 6-8 students/group) in an intimate round table format. After 15 minutes, students will move to a different table, while the grad student/postdoc stays in position. In this way students will interact with 4 different grad students/postdocs over the hour-long session. This benefits both the undergraduates, by exposing them to the diversity of research in the department they could participate in, as well as giving graduate students and postdocs valuable experience in science communication.

Course description and context of curriculum reform

CHEM 1400 (Foundations of Chemistry) is a new introductory chemistry course that will replace the existing CHEM 1251 course. The course is intended for chemistry and biochemistry majors and the estimated enrollment is 120 students. The class will be divided into two sections (9 am and 11am), taught by Professor Amy Palmer and Professor Robert Parson, and will be located in the active-learning classroom, MCDB A120. As part of an overarching curriculum reform effort in the Department of Chemistry and Biochemistry, majors within the Department will take this one semester Foundations of Chemistry course in their first semester (freshman fall), and subsequently enroll in 2 semesters of a revised Organic Chemistry sequence. CHEM 1400 is a 4-unit course with a mandatory recitation section. Students will co-enroll in a new 1-unit laboratory course (CHEM 1401), which is being designed as an open-inquiry, research-based lab. CHEM 1400 is being developed by Professor Amy Palmer.

OUTCOMES

We hypothesize that building connections among students and between students and professors, graduate student teaching assistants, and undergraduate learning assistants will positively influence students' attitudes about chemistry, as well as more generally about learning and doing science. Further, we believe that having students engage in interesting, relevant, collaborative activities will not only enhance learning, but will also foster personal connection with the subject matter and underscore the importance of the subject to future career goals. Finally, we aim to give students experience researching and communicating science in ways that are authentic to the profession. We suggest that these interventions will lead to the following tangible outcomes:

(1) Improved attitudes about chemistry, as measured by the Colorado Learning Attitudes about Science Survey (CLASS-Chem). This is a validated instrument to characterize student beliefs about chemistry and learning chemistry, as well as shifts in beliefs (to more novice-like or more expert-like) as a result of course instruction.[4] CLASS is part of the PhET Project and Physics Education Research Group at the University of Colorado and was adapted for Chemistry in 2008. We can modify this survey to include open-ended questions to more explicitly evaluate sense of identity and community. This survey has been administered to both majors and non-majors in departmental courses for many years, providing a wealth of comparison data.

(2) Improved success in the CHEM 1400 and in subsequent chemistry classes, as defined by increase in the proportion of students with C- or better in the CHEM 1400 course. We will also longitudinally track DFW rates in both CHEM 1400 and subsequent chemistry courses, and compare to historical data for the old majors course sequence.

(3) Increased retention within the major, as measured by a greater percentage of students persisting in the major and smaller decreases in the number of majors at each class level.

(4) Increased long-term connection with chemistry, for example an increase in the percentage of majors who carry out undergraduate research in later years as well as the percentage graduating with honors. We will track the amount of students who do research after each year, to look for shifts in how early students engage with research.

Trickle up and sustainability: As mentioned previously, the Chemistry and Biochemistry Department is in the process of overhauling the introductory curriculum and course sequence for majors. We have adopted a 1:2:1 sequence for chemistry majors and 1:2 sequence for biochemistry majors where students take 1 semester of general chemistry, followed by 2 of organic, followed by 1 of advanced chemistry (only for chemistry majors). If we demonstrate effectiveness of the approaches in this proposal we would like to extend these cultural shifts into the courses students take past their first semester. We also think that many of the interventions would benefit students in the non-majors track, but believe that implementation on a small pilot scale (e.g. the 120-person majors course) is more feasible to start. Our intention is to make these changes sustainable as part of a wider culture change in the Department. To this end, we have strong Departmental support (see budget justification).

Dissemination of results: In addition to locally disseminating our work through the DBER community, we anticipate trying to publish our results in the chemical education literature as well as present at conferences such as the national American Chemical Society conference or the Gordon Research Conference on Chemistry Education Research and Practice.

Timeline: Materials (in-class activities, project ideas, community-building events) will be developed in Summer 2016 for use in Fall 2016. In Spring 2017 we will analyze data on the short-term attitude, performance, and retention impacts and report results by Summer 2017. Longitudinal data collection will be ongoing. Professor Palmer will continue to work on and teach the CHEM 1400 course for the following two academic years (Fall 2017 and 2018).

References

(1) Cooper, M. The Case for Reform of the Undergraduate General Chemistry Curriculum. *J. Chem. Educ.* **2010**, *87* (3), 231–232.

(2) MacArthur, J. How Will Classroom Response Systems "Cross the Chasm"? *J. Chem. Educ.* **2013**, *90* (3), 273–275.

(3) Price, W. S.; Hill, J. O. Raising the Status of Chemistry Education http://chemed.chem.pitt.edu/wits/Documents/p2_price.pdf (accessed Apr 14, 2016).

(4) Barbera, J.; Adams, W. K.; Wieman, C. E.; Perkins, K. K. Modifying and Validating the Colorado Learning Attitudes about Science Survey for Use in Chemistry. *J. Chem. Educ.* **2008**, *85* (10), 1435.

(5) Wilson, Z. S.; McGuire, S. Y.; Limbach, P. A.; Doyle, M. P.; Marzilli, L. G.; Warner, I. M. Diversifying Science, Technology, Engineering, and Mathematics (STEM): An Inquiry into Successful Approaches in Chemistry. *J. Chem. Educ.* **2014**, *91* (11), 1860–1866.

(6) Toven-Lindsey, B.; Levis-Fitzgerald, M.; Barber, P. H.; Hasson, T. Increasing Persistence in Undergraduate Science Majors: A Model for Institutional Support of Underrepresented Students. *CBE Life Sci. Educ.* **2015**, *14* (2), 14:ar12.

(7) Astin, A. W. *What Matters in College?: Four Critical Years Revisited*, 1st ed.; Jossey-Bass, Inc.: San Francisco, CA, 1993.

(8) Graham, M. J.; Frederick, J.; Byars-Winston, A.; Hunter, A.-B.; Handelsman, J. Science Education. Increasing Persistence of College Students in STEM. *Science* **2013**, *341* (6153), 1455–1456.

(9) Kyndt, E.; Raes, E.; Lismont, B.; Timmers, F.; Cascallar, E.; Dochy, F. A Meta-Analysis of the Effects of Face-to-Face Cooperative Learning. Do Recent Studies Falsify or Verify Earlier Findings? *Educ. Res. Rev.* **2013**, *10*, 133–149.

(10) Springer, L.; Stanne, M. E.; Donovan, S. S. Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis. *Rev. Educ. Res.* **1999**, *69* (1), 21–51.

(11) Freeman, S.; Eddy, S. L.; McDonough, M.; Smith, M. K.; Okoroafor, N.; Jordt, H.; Wenderoth, M. P. Active Learning Increases Student Performance in Science, Engineering, and Mathematics. *Proc. Natl. Acad. Sci. U. S. A.* **2014**, *111* (23), 8410–8415.

(12) Warfa, A.-R. M. Using Cooperative Learning To Teach Chemistry: A Meta-Analytic Review. *J. Chem. Educ.* **2015**, acs.jchemed.5b00608.

(13) Cooper, M. M.; Cox, C. T.; Nammouz, M.; Case, E.; Stevens, R. An Assessment of the Effect of Collaborative Groups on Students' Problem-Solving Strategies and Abilities. *J. Chem. Educ.* **2008**, *85* (6), 866.

(14) Mahalingam, M.; Schaefer, F.; Morlino, E. Promoting Student Learning through Group Problem Solving in General Chemistry Recitations. *J. Chem. Educ.* **2008**, *85* (11), 1577.

(15) Beichner, R. J. *The SCALE-UP Project: A Student-Centered, Active Learning Environment for Undergraduate Programs (an Invited White Paper for the National Academy of Sciences)*; 2008.

(16) Solano, D. M.; Wood, F. E.; Kurth, M. J. "Careers in Chemistry": A Course Providing Students with Real-World Foundations. *J. Chem. Educ.* **2011**, *88* (10), 1376–1379.

(17) Bopegedera, A. M. R. P. STEMming the Tide: Using Career Week Activities To Recruit Future Chemists. *J. Chem. Educ.* **2005**, *82* (10), 1505.

(18) Tucci, V. K.; O'Connor, A. R.; Bradley, L. M. A Three-Year Chemistry Seminar Program Focusing on Career Development Skills. *J. Chem. Educ.* **2014**, *91* (12), 2071–2077.

(19) Linn, M. C.; Palmer, E.; Baranger, A.; Gerard, E.; Stone, E. Undergraduate Research Experiences: Impacts and Opportunities. *Science* **2015**, *347* (6222), 1261757.

(20) Russell, S. H.; Hancock, M. P.; McCullough, J. Benefits of Undergraduate Research Experiences. *Science* **2007**, *316* (5824), 548–549.

(21) Hunter, A.-B.; Laursen, S. L.; Seymour, E. Becoming a Scientist: The Role of Undergraduate Research in Students' Cognitive, Personal, and Professional Development. *Sci. Educ.* **2007**, *91* (1), 36–74.

(22) De La Franier, B. J.; Diep, J.; Menzies, P. J. C.; Morra, B.; Koroluk, K. J.; Dicks, A. P. A First-Year Chemistry Undergraduate "Course Community" at a Large, Research-Intensive University. *J. Chem. Educ.* **2015**, acs.jchemed.5b00280.

(23) Sadler, T. D.; McKinney, L. Scientific Research for Undergraduate Students: A Review of the Literature. *J. Coll. Sci. Teach.* **2010**, *39* (5), 43–49.

(24) Lee, S. Building Strong Bonds: Chem Club in the Classroom. *Chem. Educ.* **2009**, *14* (3), 145–149.

(25) Brown, P. Implementation of a Program for Mentoring Students in a Two-Year Chemical Technology Program by an Alumnus Enrolled in Graduate School. *J. Chem. Educ.* **2014**, *91* (4), 605–607.

(26) Layton, R. A.; Loughry, M. L.; Ohland, M. W.; Ricco, G. D. Design and Validation of a Web-Based System for Assigning Members to Teams Using Instructor-Specified Criteria. *Adv. Eng. Educ.* **2010**, *2* (1), 1–9.

(27) Beichner, R. J.; Saul, J. M.; Abbott, D. S.; Morse, J. J.; Deardorff, D.; Allain, R. J.; Bonham, S. W.; Dancy, M.; Risley, J. The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project. *Res. Reform Univ. Phys.* **2007**, *1* (1), 1–42.

(28) Runquist, O.; Kerr, S. Are We Serious about Preparing Chemists for the 21st Century Workplace or Are We Just Teaching Chemistry? *J. Chem. Educ.* **2005**, *82* (2), 231.

(29) Logan, J. L.; Quiñones, R.; Sunderland, D. P. Poster Presentations: Turning a Lab of the Week into a Culminating Experience. *J. Chem. Educ.* **2015**, *92* (1), 96–101.

BUDGET

Salary (2 months summer) for Professional Research Assistant Allie Hunter	$ 5968
Fringe benefits (37.3%) for Professional Research Assistant Allie Hunter	$ 2226
Supplies for Poster Symposium	$ 1200
ChemClub activities	$ 600
Total request	**$ 9994**

Budget Justification

The bulk of funds would be used to support the salary of Professional Research Assistant Allie Hunter (Co-applicant on this proposal). Allie has been working with Professor Amy Palmer (applicant) since October 2015 to build the conceptual framework for CHEM 1400. In collaboration with Professor Palmer, Allie will develop in class activities, the list of research projects, and recitation materials for training students for semester-long research projects, and revise these materials for future semesters. She will also help recruit graduate students and postdocs for science speed dating and help organize the activity. Finally, she will coordinate activities with ChemClub. We are requesting two months of summer support for Allie and associated fringe benefits. Allie is currently employed as a 75% PRA with a salary of $2984/month. A PRA has a fringe benefit rate of 37.3%. Professor Palmer and the Department of Chem Biochem will commit to finding funds to ensure support for Allie through next Fall semester and will explore opportunities for sustained commitment to promote expansion of interventions to additional classes in the future.

We request $1200 for supplies for the poster session so that students can print professional looking posters (40 posters), and $600 to buy supplies for Chem Club activities (supplies for demos, etc).

We would like to emphasize that the Department of Chemistry and Biochemistry is making a substantial financial commitment to course transformation. The Department is currently funding Allie's salary and has committed funds for 3 years of CAT (Critical thinking Assessment Test) administration, which will be used to evaluate gains in critical thinking.

Finally, we would like to call the reviewers attention to two other projects in order to distinguish them from this Chancellors Faculty Award. We (Palmer and Hunter) have applied for a ASSETT development grant (~ $5000) to acquire tablets for use in group activities but the Chancellor's Project doesn't depend on successful acquisition of these tablets as we are committed to developing collaborative in class activities with or without tablets. Finally, Anna Curtis is applying for a Chancellor's Graduate Award and although her project also involves CHEM 1400 and Palmer would serve as the faculty mentor, her proposal is distinct from and doesn't overlap with this proposal.