Development of Modular Student-Centered Learning Activities for a Transformed General Chemistry Curriculum

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This project aims to create student-centered activities to be implemented in our reformed general chemistry course series (CHEM 121, 122, and 123). It draws upon the research on teaching and learning, as well as internal data from the department of chemistry indicating that students are not currently achieving the learning outcomes we intend for them to achieve. The activities will be modular such that any instructor will be able to implement them in the classroom, irrespective of their chosen pedagogical methods. This will be facilitated via an instructor’s guide that will accompany each of the activities.

How the proposed work will expand my expertise as an educator (Rubric category 1):

The act of developing evidence-based, student-centered learning activities for our general chemistry series is, itself, a process of deep reflection on how students learn. This process will improve my pedagogical content knowledge; that is, it will improve the degree to which my pedagogical methods in the classroom align with the content I am helping my students to discover and learn in the course. I expect to improve my teaching outcomes by creating the activities in a manner that aligns with the scientific practice of modeling (one of the seven scientific practices identified in the Next Generation Science Standards), as well as ultimately adopting them in my own teaching in the Chemistry 12x series at WWU.

How the proposed work will enhance my professional development in other ways (Rubric category 2):

The scholarship I engage in as a faculty member at WWU is centered on the teaching and learning of chemistry, with a particular focus on quantum chemistry. This is an incredibly abstract domain of knowledge, and requires students to navigate a complex world of developing and applying models that navigate the submicroscopic (atomic-molecular scale) world, along with its manifestation at the macroscopic (human-scale) level. Yet, it is fundamental to our modern understanding of all of chemistry. By developing and implementing these activities at the general chemistry level, I will undoubtedly develop new questions regarding how students think in this domain. Thus, my efforts pertaining to this project will simultaneously boost my efficacy as an educator and as a scholar in discipline-based education research.

How the proposed work will enhance specific courses, the program, or departmental curriculum (Rubric category 3):

The Department of Chemistry assembled a task force, in Spring 2016, to specifically recommend and implement a new, three-course, general chemistry curriculum by the start of Fall 2017. This move was, in part, motivated by the desire to improve student outcomes in the curriculum (which will be discussed in the next section). It is also a transformation process that impacts the foundational course sequence in our department: general chemistry is a service-level sequence that enrolls ~ 1,000 students per quarter. Over 50 major programs across over 10 departments require students to take at least one course in the sequence. Along with our new curriculum, the activities will enhance the learning of an enormous number of students in the 12x series. I expand on this assertion in some detail below.

How the proposed work will benefit students, enhance student learning and better serve students, the department, and the university (Rubric categories 4 & 5):

Recent assessment data from within the department of chemistry indicates that students are not achieving the intended learning outcomes in a number of key areas. I will provide an illustrative example via a direct quote from the assessment and improvement report (2012-2013): “Post-assessment results further revealed that the most troublesome questions for students tended to use molecular (e.g. pictures of atoms or molecules) instead of symbolic (e.g. formulas or equations) representations.” Competence within, and translation between, these levels
of representation is notoriously difficult for students, but is essential for achieving a strong understanding of chemical phenomena. This, among other concerns within the assessment data, led our department to create a task force to choose and implement a new general chemistry curriculum. Irrespective of the identity of this curriculum, we will need student centered activities to accompany it. This need is justified by the consensus that active learning in STEM classrooms leads to favorable student outcomes. Further, student-centered learning has increasingly become the norm within our department thanks largely to the efforts of the Change at the Core (C-CORE) professional development program, which has involved 12 chemistry faculty over the past 3 years. Several faculty have created student-centered activities, in part, as a result of C-CORE professional development activities. New activities would, therefore, be well supported by our faculty. Part of this work would be to identify which important concepts have not had student-centered activities constructed for them, and address these “gaps.” Summer 2017 is the perfect time to create these activities, as the new curriculum will first be implemented in Fall 2017. In Summer 2017, I expect to construct at least 6 such activities (2 for topics in each quarter of the 12x series) to be implemented during a 50-minute class session. Instructor guides will be created for implementation in a variety of classroom settings (e.g. mostly-lecture, fully or partially flipped, inquiry-based). Thus, new instructors who may, initially, lecture a fair amount will still be able to engage students with the instructional materials (hence the “modular” nature of the activities).

The general format of these instructional modules will be arranged such that students’ initial ideas are first elicited; their conceptualizations of a particular chemical phenomenon (e.g. the model of the atom) will be probed. The instructor will then draw upon these initial ideas to introduce the exploration phase of the activity; this is the “heart” of the activity where students will grapple, in small groups, with a set of questions scaffolded in a manner that guides them toward the desired learning outcome. Within this phase, they move toward building a model that is predictive and explanatory in the context of some chemical phenomenon (e.g. using a PhET—rigorously assessed simulations for physics, chemistry, and biology—simulation for different models of the atom in conjunction with a live demonstration of the emission spectrum of hydrogen). Finally, the class will engage in a reflection and revision discussion in which the student groups will compare and contrast their initial ideas with what they have uncovered throughout the course of the activity, and will suggest ways in which the scientific model(s) under consideration could be extended or revised under new conditions (e.g. the spectrum of a many-electron atom, such as Xenon, is presented—which requires extension beyond a common model of the one-electron atom or ion discussed in general chemistry). This reflection and revision is an important component of model based inquiry, in which students discover the utility and limitations of scientific models. The general sequence outlined above is inspired, in part, by the highly successful, well-researched, Physics and Everyday Thinking curriculum used in the SCED 201 course at WWU. I expect that, by fundamentally grounding the development of these activities in the most cutting-edge research on teaching and learning, that students and instructors alike will notice measurable, and satisfying improvements in outcomes. In fact, a recent (2014-2015) assessment report noted that students’ improvement on online-homework items in the area of kinetics, thermodynamics and equilibrium “is at least partly due to increased emphasis (through student centered activities) on this subject by chemistry C-Core faculty teaching in the general chemistry sequence.” We know active learning leads to improved student outcomes; now, we simply need a curriculum and student-centered activities to help facilitate it.

How the proposed work will promote the mission of the department, college, and university (Rubric category 6):

The tenets of this work are perfectly aligned with three complementary aspects of the departmental, college, and university strategic goals and missions, as they all explicitly, or implicitly, state student centered learning as an important part of the student experience at WWU. Take, for example, the following excerpt from CSE’s strategic plan: “Incorporate student-centered and inclusive learning practices in the curriculum.” It is my expectation that, by developing modular student-centered activities based on robust research on teaching and learning, I will effectively and positively contribute to this mission for a large number of students at our institution.