Course Enhancement: Supplementing Existing General Chemistry Laboratory Activities with Virtual Laboratory Experiences to Increase Student Engagement.

Principal Investigator: Steven Hegwood, slh099@shsu.edu

Budget: $1500.00

STEM Courses Involved:

Primary: General Chemistry 2 Laboratory, CHEM 1412, lab sections 11-22
Secondary: General Chemistry 1 Laboratory, CHEM 1411, lab sections 11-25

Project Narrative:

Executive Summary:

Improvement of the existing remote learning activities in the General Chemistry laboratory courses is needed. The process will begin with the General Chemistry 2 course, CHEM 1412, since a larger portion of the existing hands-on experiments lend themselves to direct supplementation with virtual lab activities. The virtual activities will be developed using *Chem Collective Virtual Labs* and, to a lesser degree, *PhET Interactive Simulations*. The need to develop virtual lab activities is the result of the currently mandated hybrid model of instruction, but following the eventual return to normal instruction, the developed materials will be used as active learning prelab activities to better prepare student for the hands-on experiments.

Student engagement and completion rates of course assignments are expected to increase as a result of using active learning practices to replace portions of the course that are currently passive. Existing remote course activities provide little opportunity for students to actively engage with the material in the same way that they would in a hands-on laboratory experience. Virtual lab activities have been shown to effectively familiarize students with laboratory practices, allowing them to work more efficiently in the laboratory by reducing extraneous cognitive load while working in the laboratory (Hubacz, 2004).

The success of the project will be determined by the comparison of remote activity completion rates by students who completed the course before inclusion of virtual labs to those of students who complete the course following implementation.

Project Narrative:

Rationale:

During recent semesters, the General Chemistry laboratory courses have been forced to implement a fully remote (Summer 2020) or hybrid (ongoing) instructional model, resulting in the use of stopgap implementation of course materials that have fallen well short of an authentic laboratory experience for students. The current remote activities involve the processing of experimental data that was collected on the students' behalf, with explanations and video presentations of how the data were collected. While the current methods achieve the goal of presenting laboratory topics, they lack the same connection to laboratory process and practice.

In the current state of the General Chemistry laboratory courses, students meet on an alternating biweekly schedule to perform traditional, hands-on laboratory activities but work remotely on an individual basis during the weeks that they are not present in the laboratory. The asynchronous presentation of selected course materials has anecdotally contributed to a lack of student engagement, and lower completion rates of course assignments. The proposed course enhancements will involve student collection of data in a virtual environment that simulates the use of common laboratory equipment and practices. Once the requirements for hybrid instruction

are lifted by the university, the materials developed during this project will continue to be used as prelab activities to prepare students for traditional, hands-on lab experiences.

It has been suggested that virtual laboratory simulations are at least as effective as real laboratory activities in terms of familiarizing students with the experimental process, providing students with a safe experimental environment, allowing students to conduct experiments individually, and presenting symbolic presentations of course content (Tatli & Ayas, 2013). Brinson (2015) examined 56 studies and determined that learning outcomes can be achieved at an equal or greater frequency with non-traditional lab practices (virtual and remote). When used in conjunction with traditional, hands-on lab practices, virtual lab activities can serve as primers to cognitively prepare students for the instruction to come.

In the remote and hybrid instructional models used since Summer 2020 and continuing into the Spring 2021 semester, parallels can be draw with the in-person laboratory symposia of the distance learning program studied by Barros, Read and Verdejo (2008). They concluded that the use of web-based, virtual experimental environments helped to familiarize students with experimental reasoning processes, requiring less time in the laboratory to understand the nature of the experimental work.

Materials and Methods:

Course materials that parallel laboratory experiments currently being used in the General Chemistry laboratory courses will be developed that use the *Chem Collective Virtual Labs* (sponsored by the National Science Foundation) and *PhET Interactive Simulations* (developed by University of Colorado, Boulder). Both are offered free of charge by the developers.

These resources will be used to provide students with a virtual experience that is analogous to the procedures of the hands-on experiments currently performed in the SHSU General Chemistry lab courses. When in-person class meetings are not possible the virtual labs will serve as replacements for the hands-on experimental procedures. The virtual activities will be used as prelab primer activities when in-person meetings are possible.

Expected Results:

It is expected that student engagement with increase using active learning practices. At the conclusion of the Spring 2021 semester, student completion rates and average scores for course assignments designated as *remote* will be compared to those from previous semesters. Only students who complete the course will be included in the comparison study, regardless of final course grade. Cited literature indicates that student performance is not significantly affected positively or negatively when using non-traditional methods, so differences in student performance will be attributable to differences in engagement.

Budget and Budget Justification:

Based on earlier work, it is expected that approximately 5 hours will be required to research, develop, test, and implement virtual lab activities to supplement each of the nine experiments included in the current CHEM 1412 laboratory curriculum, totaling approximately 45 hours. Based on the rate of $32.87/hour previously paid by the STEM Center for similar work done to develop the Chemistry Summer Bridge course, the total labor budget for the project is $1479.15. Additional time to complete the *Post Implementation Reporting Process* will surpass the grant maximum of $1500.00. If unused allocated time is available or expected to be available, it will be used to begin development of similar materials for the General Chemistry 1 laboratory course, CHEM 1411. Because the virtual and simulation applications are provided by the developers at no charge, no additional funds are required for materials.

References

Barros, B., Read, T., and Verdejo, M. F. "Virtual Collaborative Experimentation: An Approach Combining Remote and Local Labs," in *IEEE Transactions on Education*, vol. 51, no. 2, pp. 242-250, May 2008, doi: 10.1109/TE.2007.908071.

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Hubacz, F., Jr. (2004). *Reducing cognitive load in the chemistry laboratory by using technology - driven guided inquiry experiments* (Order No. 3123461). Available from ProQuest Dissertations & Theses Global. (305212108). Retrieved from https://ezproxy.shsu.edu/login?url=https://www.proquest.com/docview/305212108?accountid=7065

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