

**STEM CENTER – Teaching Enhancement Grants
2022 Faculty Mini-Grants Application
Project Report**

1) Proposal Title:

Scholarship of Teaching and Learning: Graphical analysis and interpretation in General Chemistry II via virtual chemistry experiences on kinetics and chemical equilibria.

2) PI Name: Adrian Villalta-Cerdas, Assistant Professor of Chemistry, axv067@shsu.edu.

3) Current and Pending Support:

The PI does not have current or pending support that directly addresses the proposed project in this application.

The following is a list of educational projects the PI has at the moment:

Current: Reformed Organic Chemistry Laboratories (ROC-Labs): an academic environment supported by cooperative learning and project-based experimentation. Source of Support: Sam Houston State University, \$14,720.

Pending: Sustainable Chemistry in College Education via Environmental Science and Smart-material Technology Laboratories. Source of Support: National Science Foundation, \$475,774.

Pending: Using single and double dice to mimic chemistry reactions: an academic community engagement project. Source of Support: The Center for Community Engagement at SHSU, \$244.

4) Budget: Funds requested \$2,000.

5) STEM courses involved in the proposal: Three sections of General Chemistry II (CHEM1412), initial enrollment Spring 2022 semester: 135 students.

A) Elements of the proposal completed according to plan:

The project was completed during the Spring 2022 semester. The teaching assistants, Sandra Simmons and Ariel Van-Sertima, worked on revising draft teaching materials. TAs were hired from the Department of Chemistry pool of assistants, and they met weekly with the PI for 6-8 hours. The concepts covered in the learning experience were kinetics and equilibrium. The experiences were completed remotely and asynchronously by the students. Two major experiences were created and were assigned 5% of the course grade. Both assignments had to be turned in for full credit. The PI would like to thank the STEM Center for funding for the student assistants, as this allowed for the student perspective to be more transparent in the obtained teaching activities and materials. The work yielded creative teaching materials that will be modified for General Chemistry I courses in Fall 2022.

B) Elements of the proposal modified from the original proposal:

The project utilized freely available chemical simulations maintained by chemistry professor Dr. William Vining (from The State University of New York – Oneonta; [link here](#)). In addition to the website resources, we created Microsoft Excel worksheets for the activities with detailed instructions on inputting the data. The worksheets facilitated variability of student results, so they all got different estimates and graphs. The approach allowed students to work together but still submit different outcomes, which deterred students from simply copying someone else work. Sample of student worksheets are provided with this report. The evaluation of the student work was completed by the PI. The project was integrated with the Academic Community Engagement initiative in the course so that both projects benefit from their individual goals.

C) Materials for one (or more) student learning activities sponsored by the grant:

I made available materials created for this project as an exemplar of the activities completed by the General Chemistry II students during the Spring 2022 semester. Files include general instructions for one activity and related worksheets and report documents. The materials underwent several revision stages, and I am providing the final and implemented versions.

D) Concluding discussion reflecting on results, lessons learned, dissemination, and directions for future development.

The project was completed within the semester's timeframe and allowed for the implementation and revision of materials used in three sections of General Chemistry II (total enrolment of 135 students). The materials were available to students after the fourth week of the semester until two weeks before the end of the semester. This accommodated the student that requested more time to work on the assignments and were limited by work and other responsibilities. Students' worksheets and reports were mostly successful and received full credit on the assignments. The average score was 91%, with a median of 100%. Only 31 students did not complete the assignments and received no credit for the project. Overall, the experience was manageable, and the instructions gave students clear guidelines and examples on how to organize their data and work. Students were actively discussing the assignments and helping each other. After the reports were submitted, students were prompted to reflect on the work done. Exemplar responses are provided in this report (see below). In the upcoming semester, novel teaching tools will be proposed for General Chemistry I, following a similar approach to the teaching tools designed for this proposal.

E) An artifact or deliverable (photo, movie, sample student work, etc.) that can be featured on the STEM Center website and included in the STEM Center promotional materials.

Please use the example report of student work and student responses to reflection prompts provided with this report (see next page).

Reflection on the ACE project

The ACE assignments encourage students to use the skills, knowledge, and dispositions learned in the classroom to collaborate with community partners in making a difference in society.

I would like to hear your feedback on the ACE project. Please answer the questions and reflect on the work you did.

Question 1 - Now that is over, what comes to mind about the overall project?

“I personally really enjoyed doing the ACE Assignments. I feel that the assignments helped me better understand the content to a fuller extent. I also feel that doing all of the work and following the directions shows whos paying attention or not. I feel the only negative thing about the ace assignments would be the rolling of the dice that took forever.”

“I think that the project overall helps you understand a little deeper how the concepts can be applied. It can be a little daunting for someone to see the excel sheets someone that has never used it but if you talk to professor Villalta it really helps. Overall I think that is a good assignment to just reaffirm the knowledge that is taught in the course.”

“I am not going to lie, the ACE assignments were difficult. The dice rolls made the collecting of data process tedious and time consuming. The graph generated from the data were, conceptually difficult to grasp at first glance. The project did allow me to explore and expand my way of thinking to an out of the box reasoning. The overall project was indeed difficult, but challenge me to reach new depths.”

“The project was a tedious assignment that made me look into how things worked exactly and get a better understanding of the subjects than what I would normally have. It is also a very graph-heavy project that forces you to really understand the relationships between variables in order to explain it.”

Question 2 - What's the most important thing you learned from the ACE project? What made it so?

“The most important things I learned from the ACE project is the basic concept of both topics, which are the most important backbone of the Chem 2 course content, as I gain a better understanding of chemical kinetics and equilibrium, it helps me a lot in understanding the conceptual parts, especially trying to interpret the graphs and really understand what's going on in those reactions.”

“I learned not to wait until the week of to complete these types of assignments. But, the project gave a realistic perspective on the topics we were learning since we had to do several trials throughout both parts. Seeing the data adjust and the tables form simultaneously helped give me a better understanding of the topics we learned.”

“The most important thing I learned from the ACE assignments was to evaluate the effect that disrupting an equilibrium reaction had on the reaction's equilibrium quotient. I had a baseline understanding of the concept, but seeing changes to the reactions, the graphs of the concentrations, and graphs of the reaction quotients made me more fully understand the impact of adding or removing products and reactants.”

“The most important thing I learned from this ACE project was actually to ask for help when I need it rather than suffering by myself trying to figure stuff out. This was especially important for putting in the excel equations. I at first was just going to put in each cell one by one rather than ask for help, but if I had done that for everything I would never have gotten it all done in time. Once I asked for help, the assignment went by much smoother.”

Question 3 - How did the assignment help you better understand the content of the course?

“I think it helped me understand by seeing the different ways that the different parts of the equation affected the reactions. For example, seeing how starting out with different concentrations of the same reactant will give you a different amount of product and reach equilibrium at different speeds. I think it also helped me read graphs better because sometimes things look better on the graph but if you don't explain the procedure that you did then the graph can be deceiving.”

“The assignment allowed me to understand what was actually going on in the reactions and this is simply due to the explanations of the graphs that accompany the project in the report. It made me have to know what is actually being depicted in the data and the graph in order to accurately report it and if there was something I had doubts on when it came to my own explanation, I found myself researching what variable or part of data im looking at to make sure I truly do understand it in a way that will allow for me to provide a proper explanation.

“The assignment helped me better understand concepts I have been struggling to try to conceptually understand since Gen Chem 1, which is enthalpy and entropy. When entropy was first introduced to me (in previous gen chem 2 courses) I could never truly understand the conceptual hold of entropy and now I have a much better understanding of entropy and the movement of reactions taking place especially from solid to liquid to gas phase. The ace assignment also helped me with the understanding of spontaneous and non-spontaneous reactions.”

“It helped me understand reactions a bit better. The graphs gave me something to connect with what we have been talking about in the lecture. Without the projects or any homework for that matter, I would just be guessing.”

“The ACE assignment help me go back and apply what I learned in class and use it to answer some questions on the Report. However, If for some reason I still did not understand I would go back and try to do more research on what I needed help and try my best to answer. Overall, It made me think about the concepts and how to apply it to the charts.”

Question 4 - What were some of the most challenging moments, and what made them so?

“Before I learned how to correctly write an equation in excel I was doing all of the math by hand. This was extremely difficult seeing as there were thousands of data points.”

“The dice rolling for sure which lead to the amount of times we had to do calculations for them as well. Also, doing my best to explain in the report with great detail as much as i could for future peers.”

“I think one of the most challenging moments would have to be rolling the dice 300 times and calculating it correctly. It happened to me in the first part where I realized I needed to go back and fix it because I was adding up the dice wrong. Eventually, I did but I really do think that the ACE Assignments also gave me the insight to manage my time more efficiently. Another thing that was challenging was sometimes you could get an error in the calculation and have to see where in the Excel document the error was occurring that took some time, but overall it was fixed.”

Question 5 - How would you support and encourage future students to complete ACE projects?

“I would encourage future students to start immediately upon receipt of the assignment and plan specific times to devote to working on the ACE assignments. I would also encourage them to be more familiar with the course material since the ACE assignments are based on the same material. Lastly, to bring thoughtful questions or possible errors to office hours instead of hopelessly panicking and trying to solve them by oneself.”

“I really liked how you have the rule that you have to do all assignments to do the next assignment it is a very good encourager technique. I've never been one to just not do assignments so I'm not sure how to encourage future students. They pay to be in college and take the class so they should just do all the assignments no matter what, but that's just how I see it.”

“I would say find the people who understand how to complete the charts and graphs as soon as possible as it is easier than doing the actual explanations.”

“Time management and determination. It may seem overwhelming but once you understand the assignment and the equations for the excel sheet, its pretty straightforward.”

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4) **Budget:** Funds requested \$2,000.

5) **STEM courses involved in the proposal:** Three sections of General Chemistry II (CHEM1412), expected enrollment is 172 students.

6) **Project narrative**

6.1) **Executive summary**

Following the success of the STEM Center-funded mini-grant project in Spring 2021, the project herein will continue with the design and assessment of virtual learning experiences for General Chemistry II. In this new project, undergraduate students will create learning modules to support student success in the course. The project aims to provide study aids to help enrolled students revise content via memorization strategies of repetition and visualization of previously covered concepts in the semester. The project proposes a thoughtful design of novel learning modules with videos, chemistry-related simulations, and chemical kinetics and equilibria assessments. All learning modules will be delivered via Blackboard. Student engagement will be tracked using the available Blackboard tools and novel evaluations to determine the impact on student learning and progress. The project's outcomes will provide evidence of the effectiveness of the virtual chemistry experiences to support memory work strategies in General Chemistry courses.

6.2) **Project Description**

Project Rationale

Chemistry presents an inherent complexity as it presents information from a macroscopic view (experiments in the laboratory) into a symbolic (chemical equations and mathematical models) and a microscopic view (models of atoms or molecules). The three levels of representation (or views) are necessary to comprehend the chemical principles in General Chemistry II of kinetics and equilibria. The project herein comes to design and implement novel learning modules to facilitate the comprehension of symbolic representations (mathematical models and graphical information) commonly encountered when studying chemical kinetics and equilibria. The main idea is to utilize freely available chemical simulations maintained by chemistry professor Dr. William Vining (from The State University of New York - Oneonta). The PI on this grant has received permission from Dr. Vining to use his website content for this project, except for commercial purposes. The project will require a significant effort from the PI and the

supported undergraduate students to design the learning modules and assess the expected learning outcomes.

Description of course and student population

The PI will teach three sections of CHEM1412: General Chemistry II for Spring 2022. Students in the course will participate in the project. The class consists of three 50-min lectures a week and one 3-hour session of experimental chemistry in a laboratory. The student body enrolled in the course is diverse regarding majors, with students from biology and biomedical-science majors (33.4%), forensic chemistry (14.9%), chemistry (6.9%), Interdis-Agri-Animal-Science & Animal-Science (7.3%), geology (5.4%), physics (4.7%), kinesiology (4.5%), among others.

Materials and Methods

1. Instructional design: The instructional design's primary goal is to develop learning modules for Blackboard to support student review of fundamental chemistry concepts. Next, assessments need to measure student mastery of the expected learning outcomes from the activities within the learning modules. The design of the learning materials will utilize free access chemical simulations maintained by chemistry professor William Vining at http://billvining.com/mmlib_sims/#gen (see Figure 1 for an example). The simulations covered a wide range of chemistry concepts but did not provide clearly structured activities with corresponding assessments. Thus, the undergraduate students supported by this grant will work diligently to design such learning materials to facilitate the learning experience for enrolled General Chemistry II students. To this end, videos and formative assessments will be created to deliver the essential instructions on using the simulations so learners can engage with the simulations. Novel evaluations will provide students with animations and videos to evaluate their understanding of graphical data and the interpretation of the results.

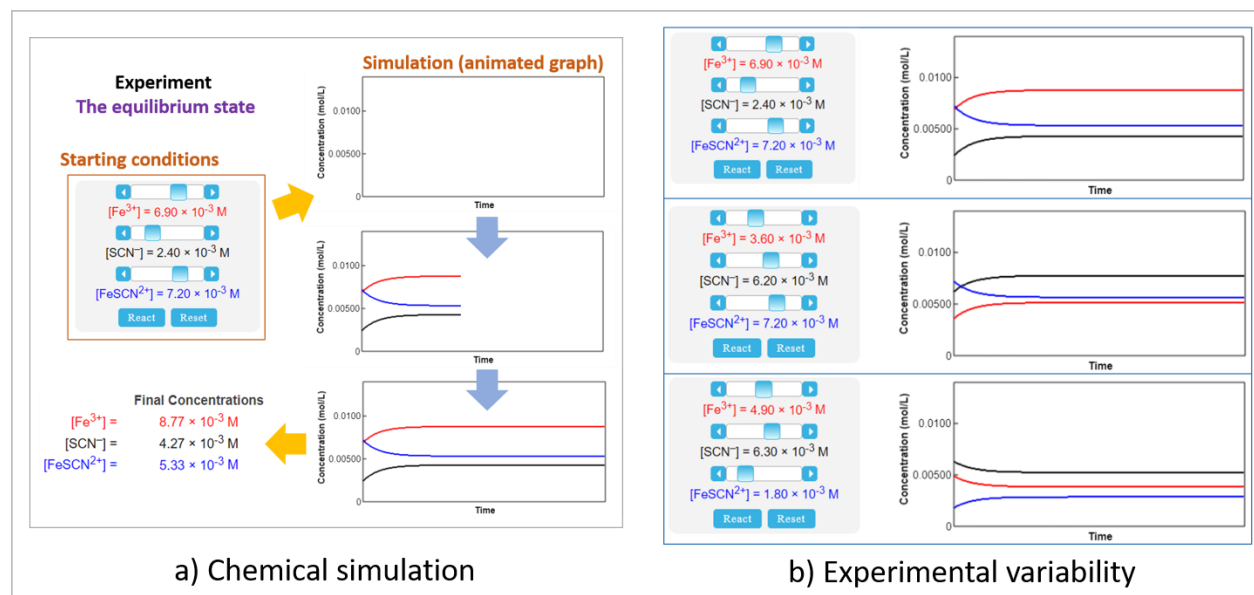


Figure 1: Example of chemical simulation and experimental variability on starting conditions and outcomes.

2. Implementation of learning modules on kinetics and chemical equilibria: The learning modules will be delivered via the Blackboard course for the three sections involved in the project. The activities are envisioned to be completed individually or in groups. Students will have to request authorization on the number of members and the roster of the groups from the PI (class instructor) before working on the learning modules.

3. Assessment of student learning: The project team (PI and undergraduate students) will design questions for online evaluations and in-class exams to measure competency and achievement of the learning outcomes. The assessments will require students to use scientific practices embedded in the virtual experiences (e.g., use models, analyze and interpret data) and provide written explanations to observed chemical phenomena related to kinetics and chemical equilibrium. The assessment approach will help determine if teaching practices and learning activities helped promote student learning of chemistry concepts.

Expected Results and Dissemination Plan

Phase 1: development of learning activities, January- early March 2022

The main objective of this phase is to develop two learning modules for the General Chemistry II course on the topics of kinetics and chemical equilibria. The activities will function as a revision of fundamental chemistry concepts via memorization strategies of repetition and visualization. All concepts covered in the class are evaluated in the final exam. Therefore, the activities will support their study sessions towards the end of the semester. The PI time allocation for this phase will be three-hour-long meetings every week with the undergraduate students (supported by this grant).

Phase 2: Implementation of virtual experiences in CHEM1412, late March 2022

This phase's main objective is to implement the novel learning modules for the General Chemistry II course. At this point, assessment data of student engagement and performance will be collected. The undergraduate students will work on the data analysis of the results. PI and students will meet for three hours every week to discuss progress and data analyses. During this phase, the undergraduate students will provide tutoring to students to help them with the activities.

Phase 3: dissemination of results, Summer 2022 and Fall 2022

The PI and the undergraduate students will present the project outcomes in chemistry conferences at the Biannual Conference of Chemistry Education (Summer 2022) and the national meeting and exhibition of the American Chemical Society (Fall 2022). Also, the learning materials will be made available to chemistry educators via peer-reviewed journal publications (e.g., Journal of College Science Teaching, Educacion Quimica) and the online community of chemistry educators *ChemEd Xchange* (<https://www.chemedx.org/>).

6.3) Budget Justification:

PI stipend: \$720. PI will organize the undergraduate students and meet over three-hour long sessions during the Spring 2022 semester. The PI will also be in charge of disseminating the project educational outcomes and helping students plan for their travel to conferences.

Stipend for undergraduates: the students will create the virtual chemistry experiences in this project and the assessment items for the learning modules; two undergraduate students will be selected from the pool of chemistry and forensic chemistry majors for the Spring semester. The undergraduate students are fundamental to the success of the project.

Spring 2022: Two undergraduate students x \$8.00/h x 8 hours/week x 10 weeks = **\$1,280.**

Total funds requested: \$2,000.