UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Modern Measurement Equipment for General Chemistry Laboratories

Title

Dr. Zachary L. Highland, Dr. Ryan Simon, Dr. Léa Gustin

Name of Submitter

(Faculty or Staff Only)

Department of Chemistry

Organization

Title: Modern Measurement Equipment for General Chemistry Laboratories Date: 8/13/2018

Name (Contact Person): Dr. Zachary L. Highland

Address: 218 Montgomery Hall

Phone Number: 337-482-56683 Email: Zachary.highland@louisiana.edu

Department/College/Org: Department of Chemistry

ABSTRACT (250 words or less):

General chemistry forms the foundation for many different majors in their introduction to quantitative sciences. Currently measurement techniques for obtaining quantifiable data from experiments is from instruments that use older and outdated methods. For instance, the thermometers for measuring temperature of reactions in the lab are filled with mercury or alcohol. When one of these break, and they do break, there are safety hazards of broken glass, and not to mention the hazards of the spilled chemicals. When this happens it is especially hazardous with the use of mercury thermometers. Stainless steel thermometers are included that have no glass parts. Additionally, instrumentation is proposed that will enhance the precision and analysis tools to our first year chemistry students. Moreover, this grant, if funded, will provide the cornerstone of teaching with Vernier equipment throughout the entire department of chemistry. With the successful funding of (SP18-01) grant, and the proposition of the Vernier equipment for the organic chemistry laboratories, a continuity of education will be established throughout the teaching of chemistry laboratories.

Proposal:

The purpose of this grant is to acquire electronic measuring instrumentation for the general chemistry laboratories. In the current proposal, thirty sets of measurement instrumentation stations are being requested for use in pairs of students during experiments in general chemistry. Specifically, our aim is to purchase electronic thermometers, pH meters, spectrophotometers, stir stations, and instrumental supporting equipment for each classroom in order to provide a complete set of basic analytical equipment to the students as they develop their experimental skills in the lab.

This proposal is designed to make two classroom sets of Vernier measurement equipment for the teaching of general chemistry. This equipment is to be used by students working in pairs during the laboratory sessions. Therefore, 13 stations will be required for each teaching laboratory. Extra equipment (4) is added to the proposal in prevention, to be used as replacement in case of breakage or failure outside of the warranty period. A classroom autotitrator is proposed for the demonstration of the concept of real world titration experience as well as to facilitate the sample preparation process prior to the lab sessions. Finally, two computers and printers are proposed for the data analysis and ability to have a centralized location for the instructor to interpret and guide students in how to analyze data as well as introducing

several important tools for data report and presentation such as graphing and redaction software. In addition it will give the instructor direct access to online resources to enhance the teaching environment and impact of the laboratories.

Vernier equipment was chosen after the successful award (SP18-01) of the advanced measuring equipment for the analytical labs (CHEM 222) with the idea of establishing a connection between the different levels of laboratories (general, organic and other upper level chemistry classes). By expanding the data collection equipment to the general chemistry laboratories, the students will get acquainted with the Vernier interface during their very first semester and will be able to advance in their chemistry curriculum more efficiently being familiar with the equipment once they reach upper level classes. This would allow for a very uniform teaching approach in the department. In addition, by using the same interface, more sophisticated instruments can be used by the instructor to demonstrate advanced concepts from the analytical laboratories.

Over 500 students make use of the general chemistry laboratories alone in Montgomery Hall every semester. Many majors including chemistry, engineering, pre-pharmacy, biology, geology, education, general studies, and physics have to take some form of a chemistry lab. Additionally, this number is expected to grow as the general chemistry laboratory classes will be split from a one semester class into a two semester class, to help students tie in skills from lecture when the lab is taken concurrently. They are coming from different educational backgrounds and many are lacking basic laboratory skills. By obtaining these robust instruments, reliable data can easily be obtained while minimizing safety hazards. By reducing these risks, instructors can spend more time focusing on the explanation of the experimental approach and skills development, as explained below.

Currently, in the labs we are using glass thermometers filled with alcohol and mercury for a total of 12 experiments during the semester. While the current thermometers serve the basic purpose of measuring temperatures, they often fluctuate and cause inaccuracies and drift over the course of an experiment. The limited precision of those thermometer also prevents us from obtaining detailed data for experiments where small changes (less than $1^{o}C$) in temperature are very significant for the final results. More importantly, these thermometers pose a safety risk as well. Like most traditional thermometers, the ones currently used are made of glass and in a lab environment, especially with freshmen not used to handling glass, accidents can and do happen on a regular basis. When they break, a safety risk is not only presented by the broken glass pieces, but the chemicals can pose a real danger to students. The risk to students is even higher when mercury thermometers are used which is why so many chemistry departments in the country have already decide to ban them from the teaching laboratories. For these reasons, stainless steel temperature probes are requested through this grant in order to provide a safer and more reliable option for taking temperature measurements. The selected probes have a working range of -40 to 135 degrees Celsius which is well within the study range of many reactions that will take place in general chemistry laboratories. These probes offer a robust mean for one of the most common laboratory measurements.

In another experiment, students learn spectroscopy, one of the most widely used quantitative techniques in analytical chemistry. The experiment allows students to detect the presence of copper in an unknown sample by making a calibration plot using known concentration standards and then using that data, determine the concentration in an unknown sample. Experiments that use Beer's law have ubiquitous applications in fields such as environmental, biological, engineering, medical, and of course chemistry

settings. Learning this technique and how it can be applied is one of the most valuable experiments for the freshmen laboratories. The current spectrophotometers used in our laboratory are antiquated and the calibration drifts well outside what is allowed for a scientific instrument, owing to the age and type of analog system, some of the instruments date back more than 20 years. In the current proposal, digital spectrophotometers are recommended having a working range of 380 to 950 nm, well suited for the types of experiments that will be employed in the general chemistry laboratories, with the ability of being expanded as the course develops and upgrades. With the interface, onsite data analysis can be performed. Higher resolution data can be obtained by using one of the two advanced spectrophotometers obtained in the Advanced instrumentation grant for CHEM 222 and 430.

The final measurement probe that is proposed is a pH sensor. This sensor is used to measure the acidity or basicity of a sample. Traditionally, for students, this is one of the hardest chapters that they will learn in Chemistry 108, thus making it all the more important to reinforce this concept in the laboratory. A fundamental lesson in general chemistry, in its own right, is how to measure the pH of a solution and develop the attained knowledge and apply this to creating titration curves and other various experiments. In the general chemistry labs, there are three experiments that are based on pH, with the expectation to grow during the 115 split into a two semester class. The pH probes currently used in the laboratories are not as accurate as the models proposed in this grant. Wide dynamic ranges exist that lead to poor data quality that do not allow for accurate experimental results and several of them appear to give faulty results after a certain time and require to be recalibrated half way through the lab session. Additionally, the present equipment only allows for single point data acquisition leading to extended experimental time which often causes the students to lose interest in the experiment. With the new proposed pH probes, a higher dynamic range is attained with better stability during the course of the experiment. Another advantage of the proposed system with regards to titrations is the ability to build the titration graph as the students are actively doing the experiment. This allows the students the advantage of actively connecting what they are learning in lectures with how titration graphs appear with what they are doing in the moment during the laboratory. Moreover, onsite data analysis can be performed actively during the lab thus enhancing the critical thinking and analysis skills of the students. This provides real time feedback from the instructor to the students during the lab, thus enhancing the effectiveness of the teaching in our department and this course. In addition to the pH meters, stirring plates are proposed here in order to allow for more efficient set-ups. Not only would it make the labs run more efficiently during the pH titration experiments but they could also be used for numerous other synthesis experiments that requires stirring such as the one for the synthesis of aspirin and that of reactions of copper, further preventing additional risk of glass breaking.

To further advance the education objectives of titrations and pH, an autotitrator is proposed. This device will be used in conjunction with the pH labs and will be demonstrated by the instructor during the laboratory lesson. Students will compare their results to the known standard graph produced by the autotitration. This device alone will be a major step forward for the chemistry department. Many universities currently use them when preparing solutions and testing the pH of chemicals during the course of experiments. Moreover, this device would quickly become essential for the preparation of stock solutions for the general chemistry and analytical chemistry classes. Accurately titrating the reagents while removing the human error will greatly enhance the information presented to students about how their standard solutions are made. Currently, our department is lacking in this capability. By obtaining this instrument, our department will be on par with other universities in the state.

Interfaces for each station are also added to this proposal. These can be run as a stand alone unit

or connected to the student's computer, tablet or phone via USB cable or Bluetooth and used with the software. This greatly expands the way students can collect data on devices in use in everyday life. The analytical chemistry grant is already providing us with a site license to be purchased in the upcoming months allowing the whole departmental to use of the software for data collection and analysis, thus offering a cost effective and sustainable solution for our university and students. As an added advantage, real time data plotting will be beneficial for students to analyze their results during the experiment rather than writing down the data points and plotting after they have left lab. Students would learn to develop critical thinking and be able to determine by themselves when they need to repeat an experiment.

Currently, there are no computers in the teaching labs, thus not allowing instructors to teach data analysis and access grades on Moodle and forcing them to rely on their personal laptops or the student's if they want to explain anything in particular. Two iMac are proposed as well for the data collection and data analysis during the laboratories. These will be used for the demonstration of data analysis by the instructor during pre-laboratory lectures as well as to allow students to send data from the classroom to themselves during the class period. Microsoft Office will be downloaded from the University of Louisiana, Lafayette website. Further data analysis can be done on this computer using the tools provided by the software as well as demonstrations of data analysis and statistics using Excel. A site license will be procured from the primary investigators of the analytical chemistry lab grant for the instrumental data analysis software. Having a centralized location will also allow the instructor look at the class data and analyze results as a class as well as accessing resources on Moodle and allow them to run the Moodle page during class. iMacs were chosen due to their ease of use and their longevity when compared to other systems. Also, the price is comparable to systems through the P.C. Depot. In addition, two personal laser printers from P.C. Depot are proposed that will allow the printing of spectra and data.

Principal Investigator and Implementation

Over the course of the grant, many factors will be monitored to ensure successful development and implementation of the material. (1) The acquisition and installation of the instruments. (2) Modification of existing laboratory material with update procedures for the new equipment. A standard operating procedure (SOP) worksheet will written by Dr. Highland and Dr. Gustin as well as calibration and maintenance procedures. In addition, online content will be developed to produce material for students to learn at home prior to the particular lab so that they are familiar with the equipment before they use them thus streamlining the laboratories. Dr. Simon will work to incorporate these new insturments into the new curriculum. (3) Training of the instructors by Dr. Highland or Dr. Gustin. Current and new instructors will be trained on how to use the equipment and how to process data using the software in order for them to effectively train the students. Dr. Highland and Dr. Gustin will hold several training sessions to inform out on the proper use and handling of the equipment. All primary investigators on this grant have extensive knowledge and experience in using these types of equipment for data collection at their previous respective universities.

The probes and data collection interfaces will be located in rooms Montgomery Hall 113 and 123 in locked cabinets until needed for a particular laboratory. When the equipment is needed, it will be moved either by one of the PI's on this grant or by Dena Battaglia (Professional Chemist) for the department. The two computers will be locked in the teaching laboratories, room 113 and room 123. The autotitrator will be housed in the stock room 121 and moved to the laboratories when needed for demonstration.

Previous STEP grants obtained from current investigators

Dr. Highland has previously been awarded the following funded grant:

Acquisition of Vernier Lapquest for Analytical Chemistry. $19,014.76, Awarded Spring 2018.

Dr. Simon has previously authored the following funded STEP proposals:

1. Organic Chemistry Laboratory Equipment Grant, R. Simon and A. Gallo, $3666.50, awarded in 2016.
2. Demonstration Equipment Grant, R. Simon, $501.64, awarded in 2017.
3. Maker Lab for Montgomery Hall, R. Simon and Y. Wang, $3649.79, awarded in 2017.
4. Whiteboards for Montgomery Hall, R. SImon, $6371.96, awarded January 2018.
5. Electronic Thermometers Grant Proposal, R. Simon and A. Gallo, $1850.00, awarded 2018.

This is Dr. Gustin's first semester at the University, and she looks forward to making many more contributions to the Department of Chemistry and the College of Science, but overall to the University of Louisiana, Lafayette as a whole.

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