Proposal: Improving Learning Outcomes through Technological Literacy in Chemistry Labs

Introduction/Context/Objectives
With 21st century’s technological advancement and scientific innovation, technology has a growing role as a medium to encourage inquiry, enhance communication, construct teaching materials, and assist students’ self-expression [1-3]. Technological literacy in chemistry labs provides equitable access to the knowledge and skills necessary for collegiate studies and career readiness. Particularly, technological literacy in the chemistry laboratory has unique functions in supporting science laboratory teaching and learning [1]. It is both highly customized and intrinsically motivating to students and well-suited to expand the learning experience in the chemistry laboratory. Students use technological tools for data capture, processing, and interpretation, for hypothesis building and investigation, and for communication and presentation. Such tools include but are not limited to digital recordings, graph processing, and model simulations and are much more powerful than hand recordings and drawings.

Technological literacy focuses on promoting students’ skills and capabilities [3, 5], i.e., problem solving, creativity, collaboration, data management, and communication, all of which are desired in higher level chemistry courses and in the global workforce. Technological literacy in the collegiate chemistry lab is realized via several different forms: multimedia demonstrations, technique simulations, laboratory interfacing systems, and instrumentation. These forms can be utilized separately or in conjunction with each other.

We are seeking to improve technological literacy in the general chemistry and organic chemistry labs through the use of instrumentation and a laboratory interfacing system. Our hypothesis is that the digitalized data acquisition and analysis techniques used in the general chemistry labs can improve students’ knowledge and application in the organic chemistry labs, thus, improving students’ overall learning outcomes in the chemistry lab course sequence and better preparing them for transfer to the 4-year institution or entering the global workforce.

Currently, GPC students planning to enter a chemistry, biology, pre-professional, or biological/chemical engineering field must take the general chemistry sequence (CHEM 1211 and CHEM 1212) followed by the organic chemistry sequence (CHEM 2641 and CHEM 2642). Each of these courses has a co-requisite lab. Students that transfer to 4-year institutions are expected to be technologically literate in basic chemistry instrumentation, e.g. absorption spectroscopy. However, students enrolled in these courses on the Decatur campus of GPC use an antiquated system of plotting graphs by hand, have no experience with laboratory spectroscopy, and have not performed product identification analysis. Thus, upon transfer to the 4-year institution, they are underprepared technologically for the upper level chemistry laboratories in their majors. The goal of this project is to introduce and enhance absorption spectroscopy laboratory techniques in the Decatur chemistry laboratories (CHEM 1211L and CHEM 2642L). Our specific aims are to:

1. Introduce absorption spectroscopy in the principal chemistry labs (CHEM 1211L);
2. Build on the spectroscopy knowledge/skillset acquired from CHEM 1211L and apply in spectroscopy application organic chemistry labs (CHEM 2642L); and
3. Improve student learning outcomes in both CHEM 1211L and CHEM 2642L.

Setting/Personnel
The absorption spectroscopy technique used will come from the Vernier Software & Technology laboratory interfacing system. Vernier SpectroVis Plus spectrophotometer adjoining with a computer workstation features a full wavelength spectrum acquisition (absorption, percent transmission, or intensity), maximum absorption wavelength determination, and standard curve plotting to determine the concentration of a solution or monitoring rates of a reaction. Vernier array spectrometer technology will be sufficient to achieve our aims in this proposal. The two labs that will be enhanced by the absorption spectroscopy techniques are:

1. **CHEM 1211L Absorption Spectroscopy and Beer’s Law:** Students will acquire the whole visible light spectrum of designed compounds using computer workstations; determine the wavelength with maximum absorption; plot a standard curve from test results of standard solution; use standard curve to determine the molar concentration of a unknown solution.

2. **CHEM 2642L Grignard Reaction: The Synthesis of Dyes (crystal violet and malachite green):** Students will use Beer’s law to quantize the products of Grignard reaction. Both crystal violet and malachite green are commercially available. Students will construct standard curved of these dyes and quantize the dye products in their reactions by measuring the visible spectrum and using Beer’s Law to calculate the concentration of dye.
Decatur chemistry lab supervisor (Dr. Y. Liang) will be responsible for the setups of these labs and provide instructional materials to lab instructors who teach these labs. In addition, the chemistry lab supervisor will work closely with lab instructors to evaluate educational results and conduct the data analysis. Decatur Science Department Chair (Dr. P. Leggett-Robinson) will serve as a collaborator providing valuable feedback in development of the organic labs (CHEM 2642L) and the dissemination of results.

**Study Design and Data Analysis**

The goal of this project is to introduce and enhance absorption spectroscopy laboratory techniques in the chemistry laboratories via digitalized data acquisition, data analysis, and presentation to improve student learning outcomes. We also hope students can sustain the learned knowledge in CHEM 1211L (absorptions spectroscopy) and apply it in CHEM 2642L (analysis of organic dyes) as well as their future studies either at the 4-year institution or in the global workplace. There is at least a three-semester gap for a student enrolled in Chem2642L after taking Chem1211L and at least a six semester gap for a student transferring or entering the workplace.

The educational results of absorption spectroscopy and Beer’s law in CHEM 1211L will be assessed in the CHEM 1211L semester final lab assessment. Currently, the CHEM 1211L lab assessment has a question to test the absorption spectroscopy and Beer’s law. Historical exam scores will be used as a comparative measure. Basic descriptive statistics will be used to analyze the data and students t-tests will be used to determine the statistically significant difference between new and historical exam scores.

To assess students’ previous knowledge of absorption spectroscopy analysis in CHEM 2642L, students will complete two separate surveys: a student profile survey that will provide general information on the student’s academic standing (including questions about whether students had used Vernier SpectroVis Plus spectrophotometer with computer workstation before, whether they acquired and plotted the spectra digitally or by hand) and a general knowledge survey of absorption spectroscopy analysis at the beginning of the laboratory class. The student profile survey will be used to compare the student populations and identify matching groups. The results of the general knowledge survey will be evaluated to determine if previous digitalized data acquisition, analysis and presentation of absorption spectroscopy will contribute to sustained knowledge and application. At the end of the CHEM 2642L, a science attitude survey will be administered to assess students’ perception/attitude about technology and digitalization in chemistry labs. The findings of this study will provide guidance and references for future lab course modification or redesign.

**Dissemination (how result will be shared)**

Results of this study will be presented to our colleagues through the appropriate college venues. In addition, results will be presented at the Georgia Academy of Sciences (Spring 2015), the American Chemical Society Annual (Spring 2015) or Regional Meeting (Fall 2015), or Georgia Science Teachers Association Annual Meeting (Fall 2015).

**Budget (see attached)**

The budget includes funds to purchase 12 Vernier SpectroVis Plus spectrophotometers and required chemicals. 12 Vernier SpectroVis Plus spectrophotometers will supply one lab section. These materials will remain in the Decatur chemistry lab and will be set up by lab staff for use.

**Reference**


