EUE Proposal
FY2019

Project ID#

19-11

Project Title

Modernizing Visible Spectroscopy for Sophomore-level Analytical Chemistry

Project Director	ID Number	Telephone	Email
Edward Navarre	800402944	6186502076	enavarr@siue.edu

Department	Campus Box	School College
Chemistry	1652	College of Arts and Sciences

Course or Program

CHEM 335

Project Co-Director	ID	Department	Email

Student Impact:	55

Multiple Submission Priority:	1

Summary:
The quantitative analytical chemistry laboratory (CHEM 335) is designed as the introduction for all Chemistry majors and minors to high-quality chemical measurement and the practices of chemical measurement. Recent work by the project director of this proposal in the department of Chemistry has given the CHEM 335 course a set of experiments that incrementally challenge student's laboratory abilities and that work as expected (this last point is neither trivial to achieve, nor unimportant to students). One of the important feature of CHEM 335 is that students are introduced to simple laboratory instrumentation such as potentiometry and visible light spectrometry. The direct experience of operating instrumentation is essential training for these students to build their competency and confidence in the chemical laboratory in preparation for the junior- and senior-level coursework in Chemistry.
This EUE proposal requests funds to support visible spectrometry instrumentation that makes better use of existing departmental resources and provides an opportunity for students to have a more meaningful experience with the equipment. The particular issue is that the existing visible light spectrometers are long since discontinued by the manufacturer and replacement parts are unavailable. As these instruments continue to age and break, repair will be impossible, and the experiments that use them will not be able to be completed. The requested EUE funds will allow the project director to build an easy-to-use interface for students to operate a more sophisticated visible light spectrometer already owned by the department. Existing spectrometers will be interfaced with software written by the project director and operated on a Raspberry PI computer.

This particular choice of equipment is important to make use of the limited space available in the laboratory.

Project Budget

Salary	Wages	Travel	Equip.	Comm	CServ	Auto	Tele	Awards	Total
10414	0	0	900	522	0	0	0	0	11836

Cost-Sharing

Salary	Wages	Travel	Equip.	Comm	CServ	Auto	Tele	Awards	Total
0	0	0	0	0	0	0	0	0	0

Modernizing Visible Spectroscopy for Sophomore-level Analytical Chemistry

Current situation

The Quantitative Analytical Chemistry Laboratory is given a 300-level designation, however, enrollment in CHEM 335 varies widely from on-track sophomores to off-track seniors in the Chemistry program. The course also has regular enrollment by Biology and Environmental Science majors. Course enrollment has increased steadily in recent years, doubling in size since 2010. The course is designed to provide a foundation of laboratory skills that will be used in successive courses (typically CHEM 365, CHEM 461, CHEM 411, and CHEM 435) and in research activities in faculty laboratories. Annually about 55 students enroll in the CHEM 335 course.

An important part of the CHEM 335 curriculum is that it introduces students to basic laboratory instrumentation. This EUE project will address the visible light absorbance spectroscopy experiment that is part of the class. Visible light absorbance spectroscopy is one of the most common quantitative techniques in many chemical laboratories. The currently used instrumentation is a few decades old and was last supported by the manufacturer in 2011. The lack of manufacturer support creates the undesirable situation in which any significant equipment failure would cause the experiment to be impossible to complete.

Continued support for maintaining the products of the proposed project will be supplied by the Department of Chemistry as part of the regular maintenance costs of the class. On-going costs will be few and the individual component costs of the equipment in this proposal are modest. Because this EUE project utilizes an existing asset in the department, there will be better utilization of departmental resources.

Proposed Project

The EUE request is for support to develop a replacement for the aging instrumentation in a way that makes efficient use of existing resources. This proposal asks for funds to create a

simplified software interface for spectrographs (detectors) that are in use in other classes in the department. This solution is proposed specifically because of the small amount of space available in the CHEM 335 laboratory. The existing spectrographs are currently attached to full-sized computers and monitors. This configuration was tested in the Summer of 2016 and found to be unwieldy and counterproductive in the CHEM 335 laboratory. The proposed solution is for the project director to write a simple interface for the spectrograph and to implement it on a Raspberry PI computer in a compact case. The result of the project is instrumentation purpose-built for the CHEM 335 class. The interface will be written in the Python language because it is well supported on the Raspberry PI and easy to maintain in the future.

Although the Raspberry PI is often viewed as a toy or "not a real computer", it is more than capable of the tasks required to operate the spectrographs. Additionally, it is inexpensive enough that it can be viewed as disposable – *i.e.*, if a student should accidentally destroy the computer, it is economically easy to replace it.

Evaluation and Dissemination

Evaluation of the project overall is challenging. Of primary importance to this project is that the instrument work well, be simple enough for a typical student to understand, and offer more learning opportunities. The most easily evaluable question is, "does this project replace the existing instrument with an equal or better instrument?" In many ways the evaluation of the project is the object itself. To borrow from Dr. Davis Baird, objects possess epistemological content.[1] A second type of evaluation will come from the learning opportunities and experiments that the instrument will make possible for inclusion in the CHEM 335 curriculum. The proposed work will allow students to see not just the results at one wavelength, but to see the entire spectrum. This possibility

[1] Davis Baird, *Thing Knowledge: A Philosophy of Scientific Instruments*. Berkeley: University of California Press (2004)

permits new experiments in which the student must decide which wavelength is most appropriate for the experiment – a simple and important pedagogical step. Additionally, the instrument will be able to operate with ultraviolet wavelengths, a region of light that is not accessible in the currently used equipment. The expanded range of wavelengths will make possible experiments that are presently not.

The part of the project that most readily can be disseminated is the interface for the instrument. This will be put into use within the Department of Chemistry immediately upon completion. The interface will also be disseminated through a chemical education outlet such as the Analytical Sciences Digital Library and made publically available via a code repository.

Budget:

Equipment: $900

Six units of the Pi-Top CEED are requested to provide five laboratory units and one development unit. The compact Raspberry PI units are very well suited to the limited space available in the teaching laboratory. Unit prices is $150.

Commodities:$522

The first two items are the memory and accessories for the Pi-Top CEED to make it a functional computer. The coupler (third item) is necessary for connecting the existing spectrographs in a way that is suitable for the CHEM 335 class. The coupler will be manufactured by the project director.

Six units ($12.00 each) of microSDHC memory cards. These are fungible resources.

Six units ($40.00 each) of keyboard+trackpad from Adafruit. This specific model is space-saving and known to work well with the Raspberry PI.

Five units ($30 total) of machined couplers for the spectrographs. This will be a custom-machined plastic item.

Salaries: $10,414

One month of faculty effort is requested for the project director to develop the code for the interface and to manufacture the couplings. One and a half months of GA time is requested so that a student can field test the instrument, provide feedback (debug), and write instructions suitable for teaching laboratory use. Ideally this would be a GA who has been a TA for the CHEM 335 class.

$7314 one month project director salary for development

$3100 1.5 month GA tester

EDWARD C. NAVARRE

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Southern Illinois University Edwardsville
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Education

2002 Ph.D., Chemistry, University of Vermont; Burlington, VT
Thesis: "Design and Spectroscopic Characterization of Z-Pinch and Theta-Pinch Plasma Atomization Cells for Direct Solids Analysis"
Advisor: Dr. Joel Goldberg

1995 B.A., Chemistry, McDaniel College (Founded in 1867 as Western Maryland College)

Positions Held

2014 – present Associate Professor, Southern Illinois University Edwardsville, Edwardsville, IL

2008 – 2014 Assistant Professor, Southern Illinois University Edwardsville, Edwardsville, IL

2006 – 2008 Post-doctoral Fellow and Technical Staff. University of Palermo, Palermo, Italy
Advisor: Dr. Giuseppe Filardo.

2001 – 2005 Associate in Science Instruction. Middlebury College, Middlebury, VT

1995 – 2001 Graduate Assistant. University of Vermont, Burlington, VT.
Advisor: Dr. Joel Goldberg.

Publications (* since joining SIUE; ‡ SIUE student author)

*Robert Mackin‡, Julie Zimmermann Holt, Edward Navarre, Victoria Weaver‡, Michael Shaw "Sourcing Prehistoric Ceramics from Western Illinois Through FT-IR Spectroscopy and Developed Chemometric Methods" *Illinois Archaeology*. **2014**, *26*, 181-207.

*Marcelo J. Nieto, Chongying Li, Timothy McPherson, William M. Kolling, Edward C. Navarre. "Preparation and characterization of inclusion complexes of *N*-substituted-benzenesulfonyl heterocycles with cyclodextrins" *Austin Journal of Analytical and Pharmaceutical Chemistry*. **2014**, *1(2)*, 1-8.

*Edward C. Navarre, Paige Wallace‡. "A Non-equilibrium Approach to Temperature Calibration for Tungsten Filament Atomic Spectrometry" *Spectroscopy Letters*. **2014**, *47*, 314-323.

*Navarre, E. C.; Bright, L. K.‡; Osterhage, A.‡ & Lada, B. "Development of an N-methyl pyrrolidone based method of analysis for lead in paint" *Analytical Methods* **2012**, *4(12)*, 4295--4302.

*E. C. Navarre and J. M. Goldberg. "Design and Characterization of a Theta-Pinch Imploding Thin Film Plasma Source for Atomic Emission Spectrochemical Analysis" *Applied Spectroscopy*. **2011**, *65(1)*, 26-35.

*A. Galia, E. C. Navarre, O. Scialdone, G. Filardo, and E. Monflier. "Complexation of phosphine ligands with peracetylated β-cyclodextrin in supercritical carbon dioxide: effect of temperature and cosolvent on the equilibrium constant" *Journal of Supercritical Fluids*, **2009**, *49*, 154.

Navarre, E. C.; Galia, A.; Scialdone, O.; Filardo, G. & Monflier, E. "Inclusion complexes of triphenylphosphine derivatives and peracetylated-β-cyclodextrin in supercritical carbon dioxide" *Journal of Physics: Conference Series*, **2008** , *121(2)*, 022022.

Galia, A.; Navarre, E. C.; Scialdone, O.; Ferreira, M.; Filardo, G.; Tilloy, S.; Monflier, E. "Complexation of Phosphine Ligands with Peracetylated β-Cyclodextrin in Supercritical Carbon Dioxide: Spectroscopic Determination of Equilibrium Constants" *Journal of Physical Chemistry B* **2007**, *111*, 2573.

Presentations (* since joining SIUE; ‡ SIUE student author)

*Stephen Kukielski‡ and Edward C. Navarre. *The Effects of Various Heating Methods on Atomic Absorption Spectroscopy*. 40th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, February 22, 2016. (**undergraduate Boumann award winner**)

*Bobby Douglas and Edward C. Navarre. *Characterization of Nickel and Chromium on a Tungsten Filament Atomizer*. 40th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, February 22, 2016.

*Marwah Abdulateef and Edward C. Navarre. *The Analytical Studies of a Tungsten Filament Atomizer for Manganese Analysis by Electrothermal Atomic Absorption Spectrometry*. 40th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, February 22, 2016.

*Reema Shakya‡ and Edward C. Navarre. *Development of a Direct Analysis Method for Copper in Serum by Tungsten Filament Electrothermal Atomic Absorption*. 38th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, March 24, 2014.

*Paige Wallace‡ and Edward C. Navarre. *Time-dependent Temperature as a Tool for Fundamental Atomization Studies on a Tungsten Filament Atomizer*. 37th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, March 11, 2013.

*Jacob Heacock‡ and Edward C. Navarre. *Minimizing Interference During Cadmium Atomization by Electrothermal Atomic Absorption on a Tungsten Filament.* 36th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, April 23, 2012.

* D. Poci‡, E. C. Navarre. *Metal oxide interferences on lead analysis in tungsten filament atomic absorption spectrometry.* ACS Midwest Regional Meeting, St. Louis, MO, October 21, 2011.

*Edward C. Navarre. *New Tricks from Old Ideas in Elemental Analysis.* Invited seminar to the SIUE School of Pharmacy, Edwardsville, Illinois, April 22, 2011.

*Amanda Osterhage‡, Derek Poci‡, and Edward C. Navarre. *A Fast Method of Lead Analysis in Paints by Sample Dissolution in Organic Solvents.* 35th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, April 4, 2011.

*Edward C. Navarre, Bradley Noble. *Portable Electrothermal Elemental Analyzer for Clinical Applications*. 2010 SIU Carbondale Technology and Innovation Expo, Carbondale, Illinois, October 8, 2010.

*Edward C. Navarre. *Pinch Plasmas as Spectroanalytical Tools*. SIUE Department of Physics Colloquium. April 23, 2009.

*Edward C. Navarre, Leonard Kofi Bright‡, and Adam Grandidier‡. *Miniaturization of a Theta-Pinch Plasma Atomization Cell*. 33th Annual William J. Probst Memorial Lecture, Bouman Symposium, SIUE, March 31, 2009.

Grants Awarded

SIUE EUE Grant "Modernizing the Quantitative Analytical Chemistry Laboratory Curriculum" funded $10,848, April 2014.

NIH R01 award "Transplatin: A Novel Agent to Mitigate Cisplatin Toxicity" PI: Vickram Ramkumar; Co-PIs: Leonard Rybak, Debashree Mukherjea, Teresa Liberati, Raymond Baggs, Steve Verhhulst, Sridar Chittur; Sub-contractors: Timothy McPherson, William Kolling, Edward Navarre. Funded $2,687,996, July 2013. McPherson, Kolling, and Navarre are sub-contracted for $45,561.

SIUE Vaughnie Lindsay New Investigator Award "A Tungsten Electrothermal Atomizer for Trace Element Determination of Solvent Extracted Samples" funded $12,500, July 2010.

NSF MRI-R^2 "Acquisition of Raman and Infrared Microscopes for Interdisciplinary Research" PI: Julie Holt; Participants: Edward Navarre, Michael Shaw, Judy Zhang, Luci Kohn, Cory Wilmott. funded $572,417, March 2010.

SIUE Summer Research Fellowship "Construction of a Pulsed Electrical Discharge for Atomic Spectrochemical Analysis" funded $4000, June 2009.

SOUTHERN ILLINOIS UNIVERSITY
EDWARDSVILLE

Date: 19 January 2018

To: EUE Review Committee

From: Leah O'Brien

Re: Letter of Support for EUE project from Ed Navarre

I strongly support the EUE proposal submitted by Prof. Ed Navarre, "Modernizing Visible Spectroscopy for Sophomore-level Analytical Chemistry". If funded, this project will replace old (20+ years), bulky, outdated, low-quality Spec-20 spectrophotometers with modern, spectrophotometers run by programmable Raspberry PI micro-computers. The new equipment will be essential for new experiments in Chem 335 that will be developed by Dr. Navarre.

The work described is consistent with the funds that are requested, and funding for Dr. Navarre and a graduate student is reasonable and appropriate. I am confident in the successful development and implementation of the new spectrophotometers.

SOUTHERN ILLINOIS UNIVERSITY EDWARDSVILLE

COLLEGE OF ARTS AND SCIENCES, OFFICE OF THE DEAN

To: Excellence in Undergraduate Education

From: Greg Budzban, Dean, College of Arts and Sciences

Subject: Dean's Memo of Support

Date: 12 January, 2018

The College of Arts and Sciences supports the application of Dr. Navarre for an EUE grant to allow the development of an easy-to-use interface for students to operate a visible light spectrometer already owned by the department. This proposed project makes use of existing equipment and is envisaged to make use of the laboratory space that is available. The project supports the focus of SIUE and the College of Arts and Sciences on expanding opportunities for experiential learning.

Campus Box 1608 Tel: 5047 Fax: 5050

Prior EUE Support

Project Director	Project Number	Award Amount	Project Dates
Edward Navarre		10848	FY 2015

Prior Results

Title: Modernizing the Quantitative Analytical Chemistry Laboratory Curriculum, Project Director: Edward Navarre, Project Number: Total $ 10,848, Period of support: FY 2015 Summer 2015

Project and Outcomes

The FY2015 EUE funded the development of a new set of experiments, materials, and a manual for CHEM 335. Two new experiments were written by the project director, tested by a GA student, and implemented in CHEM 335. Electrodes purchased with EUE funds permit students to perform an experiment that was previously not possible. The manual was also rewritten for clarity. One of the aims of rewriting the experiments was to make all of them truly quantitative and based on certified standards. This goal was very appropriate given that the class is titled "Quantitative Analytical Chemistry Laboratory".

An example of the outcomes of the EUE grant can be seen in the student performance on one of the experiments in the course, comparing data from 2013 (previous materials and manual) to 2015 (after implementing the project). Student performance is overall about the same, which is to say that the student population didn't change much in 2 years. However, it was observed that the number of extremely poor results in 2015 was smaller. The standard deviation of the student determinations (one of the graded components) fell from 1.39 to 1.02 in the 2013 to 2015 transition with a concomitant increase in student grades. The data confirms the suspected unreliability of the unknowns previously used in the course; they had become heterogeneous. The newly purchased materials simply performed better.

The new materials, experiments, and 63-page manual have been in use for three years as of this writing which corresponds to about 150 students. I have worked together with graduate teaching assistants each year to refine the experimental instructions and conditions to make the laboratory experience more valuable for students. Student results in CHEM 335 have consistently improved over the past three years with better rates of on-time completion, less confusion during the experiments, and high quality results on the experiments.

The overall result of the EUE project is that grades are now a real evaluation of the student's ability to perform the quantitative laboratory work. The new sequence of experiments gradually increases in complexity over the semester and exposes students to a broader range of chemical examples than previously.