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The Arsenic Project: Creating Authentic Research Experiences for First-Year Undergraduates

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Julian Tyson’s arsenic project is an outstanding example of integrating research into multiple levels of teaching.

Introduction UMass’ mission is to provide an affordable and accessible education of high quality and to conduct programs of research and public service that advance knowledge and improve the lives of the people of the Commonwealth, the nation, and the world. I think that every tenure-system faculty member of such an institution should strive (a) to contribute to both the undergraduate and graduate teaching mission, (b) to publish the results of a relevant research program, and (c) to reach out to students at early stages and encourage them to continue their education to the bachelor’s level, doctoral level and beyond. I view this latter activity as crucial for faculty in the STEM disciplines, given that the US is facing a gathering storm in terms of (a) the country’s position as a world leader in science and technology, and (b) the economic benefits that accrue from such a leadership position. For the conscientious faculty member, there are clearly time constraint issues. How is it possible to contribute meaningfully to the teaching, research and outreach missions of the institution and still have time to eat and sleep? My perspective on this conundrum is to find ways to integrate research with teaching and learning. I recognize that this may not be possible for every faculty member, but one goal for this aspect of the arsenic project is to show that it can be done.

Over the past four years, I have been experimenting with the integration of research with teaching and learning with the goal of investigating the extent to which one faculty member can create authentic research experiences for large numbers of students (both undergraduate and earlier) that motivate them to continue with their study of STEM subjects and to seek out further research opportunities.

The activity is designed to provide elements of an authentic research experience, including the opportunity (a) to become familiar with the relevant big picture, detailed background, and previous work done, (b) to conduct a series of experiments in which the designs of the later ones can be based on the outcomes of earlier ones, (c) to draw conclusions, summarize the findings, make suggestions for further work and (d) create a written document containing the material of interest to the broader community. Other features of an authentic research program included are: (a) inexperienced workers work alongside the more knowledgeable workers, from whom they can obtain guidance and information as needed; (b) participants are part of an active community of scholars who meet to discuss their findings and to examine critically new knowledge in the field; and (c) participants take some responsibility for the design and implementation of the experiments.

Topic and program There are two issues to consider: the research topic and the program structure. Environmental issues catch students’ attention as there is often a personal health connection. I have found that issues surrounding the environmental and analytical chemistry of arsenic compounds have been very suitable as the basis for the student’s investigations. The bio-geochemical cycling of arsenic is one of my own research interests and so the students’ participation is described as joining my research group. This means that I assign the topics on which each group works.

Participants sign up for a one-credit semester-long honors colloquium in which 2 - 4 first-year undergraduates work with 1 - 2 juniors and a graduate student mentor. Over 300 undergraduates have participated to date; about 75% are first-year students. Themes include the leaching from pressure-treated wood and movement in the soil, the uptake by plants and insects, the removal from contaminated drinking water and reliable determinations at single digit microgram per liter concentrations with low-cost, portable measurement technology.

Impact Students who participated in 2005-6 filled out a questionnaire at the end of the semester. They were very satisfied with the experience. Here are typical comments:

This project was extremely informative and interesting and I would recommend it to anyone, especially first-year students looking for a place to start getting research experience.

I really enjoyed working as part of a group on the arsenic project. It was very interesting to me, and I learned a lot about the hard work that doing research requires. Overall, it was a positive experience, and I would enjoy doing more research in the future.

I really feel that this project has made me more confident in seeking out other laboratory activities and research in the future. I feel I have benefited tremendously by having my first lab experience in an environment with friends and others who were in the same position, as well as the ideal balance between close supervision and freedom to perform the lab work. I hope other students will have the opportunity in the future to benefit as I have from this project.

I have not followed what has happened to the participants in terms of seeking out other research experiences or staying in sciences. I am certainly writing more letters of
Other facets of the program As well as the semester-long undergraduate research projects, I have also been able to create summer REU-type experiences for underrepresented minorities from other institutions. So far, nine undergraduates and two high school students have participated. In the summer of 2008, a middle school teacher participated in a research experience that will result in further work by her students. This is, in some ways, where the program started, as the first arsenic project activities, other than research by my graduate students, were done by middle school teachers and students participating in the NSF-funded Graduate Students in K-12 Education (GK-12) program that was known locally as STEM Connections (2002-05). With the help of a no-cost extension and funds from another NSF grant and UMass, the arsenic projects continued for another year with two teachers. The arsenic topics have also been incorporated into the STEM RAYS after school science clubs and summer academies. The responses from the juniors are much the same as those from the first-year students, and those from the graduate students show benefits in terms of their professional development as teachers, mentors and researchers.