Supporting Interdisciplinary Undergraduate Research through the Materials Science Center at UW-Eau Claire

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The University of Wisconsin-Eau Claire has a well-established history of valuing and supporting undergraduate research. UW-Eau Claire was designated as "The Center of Excellence for Faculty and Undergraduate Student Research Collaboration" in 1988 by action of the Board of Regents of the University of Wisconsin System. This "Center of Excellence" was built on a quarter-century tradition of engaging students in collaborative research with faculty scholars who incorporated research into the undergraduate experience. Students at UWEC understand the value of collaborative research as a high impact practice and have invested in supporting it. Each year students pay a differential tuition (DT), a student-approved fee that provides UWEC with approximately $900/per student in annual funding to support enhanced student experiences. Approximately $900,000 of the differential tuition is used to support student/faculty research across the campus, primarily for student stipends. Each spring the university showcases its research collaborations at the Celebration of Excellence in Research and Creative Activity (CERCA) event. Typically around 700 students present their research results at CERCA each year.

In the physical and biological sciences, student-faculty research often requires instrumentation. At UW-Eau Claire, the Materials Science Center (MSC) plays an important role in supporting undergraduate research, by providing and supporting instruments used predominantly in Materials Science related research. The MSC, a user facility with nearly $4.5 million in state-of-the-art materials instrumentation, typically supports 40-50 students conducting research in physics, materials science, biology, chemistry, geology, geography and anthropology, and environmental and public health annually. Facilities include light microscopy, electron microscopy, various elemental and chemical spectroscopy facilities, nanoscience tools, and mechanical materials testing equipment. The Center has acquired these instruments using funds from a variety of sources: most were funded by competitive peer-reviewed grants (primarily via the National Science Foundation – Major Research Instrumentation Program), some were obtained through collaborations with industry, and a few were funded by internal funds.

The Materials Science Center was formed in 2004 soon after an X-ray Photoelectron Spectroscopy System and a Scanning Tunneling Microscope were funded by separate NSF-MRI grants. In 2008 the State of Wisconsin provided funding to UW-Eau Claire for the NanoSTEM initiative. The NanoSTEM initiative is designed to enhance economic development in the Eau Claire region and the state of Wisconsin, and demonstrates how higher education can be a catalyst for economic growth through targeted programs that benefit students and businesses.

The initiative provides base budget funding for staff, instrument maintenance and instrument acquisition for the Materials Science Center.

In order to provide access to the instrumentation for faculty and students across disciplines, the Materials Science Center is responsible for scheduling, maintenance, and repair. The acquisition of new instruments is based on teaching, research, and industrial needs and also based on the availability of external funding. Facilities with this quantity of instrumentation require faculty and staff expertise to provide extensive routine maintenance, and since the instruments are used by experts and novices (that is, students) alike, the instruments do sometimes fail and need rapid repair in order to keep projects on schedule. While the MSC provides these services with no charge-back to the departments, maintaining instruments of this caliber requires a significant investment. Service contracts, which typically average about 10% of the cost of an instrument on an annual basis, are prohibitively expensive (we maintain service contracts only on the Transmission Electron Microscope and one of the Scanning Electron Microscopes), so most instruments are maintained and repaired in-house. Nonetheless, the occasional service call that exceeds $10,000 is not uncommon. Maintenance and repair of instrumentation is funded internally, with some additional support from service fees paid through industrial collaborations. With the two service contracts totaling over $40,000, the MSC will typically spend around $60,000 annually on upkeep and maintenance of instrumentation.

The key component to make all of this work is the Materials Science Center staff. The staff currently consists of two fulltime PhD scientists who play many roles in the operation of the Center. The staff works with industrial collaborators (about 20/year), maintains and repairs equipment, trains students on instrumentation and provides support for the Materials Science curriculum. Their training, occasional mentoring, and ad hoc advising of students profoundly impacts undergraduate research enabled by the Center.

Beyond supporting the traditional one-on-one student-faculty research model, the instrumentation is becoming more extensively used in coursework as faculty integrate undergraduate research into the curriculum. Traditional undergraduate research projects that have been supported by the Center include investigating the synthesis of silicon carbide nanowires, measuring electrical properties of nanowires, investigation of defects in superconducting wires, graphene, functional nanoparticles for photovoltaics, smart polymers, analysis of garnets, analysis of nano-particulates from the environment, 3D mapping of impurities in quartz, analysis of carbides in shock melted meteorites and many others.

Courses in physics, chemistry and materials science that take advantage of MSC instruments allow more students to participate in the research process. In one Chemistry course, students conducting research done as part of the class, using MSC instrumentation to study Cu(I) and Cu(II) binding by methanobactin were included on as co-authors on a published paper in the journal *Biochemistry.* Other class-related projects have included microbead analysis from skin care products, comparing composite tennis rackets, characterization of co-polymers, analysis of

sugar substitutes, and the orientation of polystyrene nanospheres as a function of sample preparation. One result of this integrated approach is that demand on the instruments is increasing: there are now weeks during the semester when the Scanning Electron Microscope is reserved nearly 100% of the time during a typical workday.

The MSC also provides support for faculty-student research projects at other regional undergraduate institutions. For example, faculty from two other institutions have used the X-ray Photoelectron Spectroscopy System and the Scanning Electron Microscope to enable their undergraduates to study thin film growth of oxide materials. As funding for new instruments becomes ever more scarce, user facilities like the MSC, can help to fill regional needs for access to instruments.

All users schedule instruments via an online scheduling system, easily accessed on the web. This allows students and faculty access to readily know when instruments are available. The scheduling system allows MSC staff to anticipate when students may need additional help, by looking at who will be using the instrument and what the project is. The system allows the tracking of instrument use and scheduling of maintenance. For example, this allows the staff to anticipate when an SEM filament may need to be replaced so it can be done near the end of its lifetime and in between scheduled users.

As the MSC's collaborations with local industry grow, opportunities to involve undergraduates in applied research projects emerge. These projects are typically a development project or one that provides additional information about a product or process. Examples of these kinds of projects include failure analysis of metal parts, corrosion analysis, and determining the source of contamination in a process. These applied research projects provide value to the industrial partner but they also offer students an opportunity to gain hands-on experience working on an applied project of interest to industry. These projects involve both a faculty mentor and a project mentor from the industrial partner.

The MSC provides valuable support to the undergraduate research effort, particularly in the physical sciences, at the University of Wisconsin-Eau Claire by providing access to a wide range of instrumentation. The user facility model used by the MSC is commonly used at research institutions within specific disciplines. This model can work well at undergraduate institutions when the instruments are used for research across multiple disciplines.