Enhancing the Undergraduate Experience for Advanced Education and Research Careers

Brown, H.J. and Cheney, A.

Department of Engineering Technology and Industrial Studies
Middle Tennessee State University
Murfreesboro, TN
hjbrown@mtsu.edu

Abstract

Undergraduate research has been determined at many academic institutions and funding agencies as a focal point for quality education (NSF 1996). Integrating research has become an essential element in developing students for technical service careers and advanced degrees. The industry professionals hiring students from the Concrete Industry Management (CIM) program at Middle Tennessee State University (MTSU) and the recent graduating seniors expressed a need for high level training of laboratory quality control and technical research. The skills necessary for graduates to become lab managers, research consultants, or graduate students were touched upon in sophomore fundamentals lab but long forgotten by graduation. Actions were taken within the curriculum that can serve as a model for other institutions to follow when considering active undergraduate research programs and the benefits therein.

Steps taken in the curriculum included development of a *Senior Concrete Laboratory* which included 1) industry collaboration 2) multidisciplinary collaboration 3) technical writing and presentations and 4) laboratory certifications. Industry collaboration allowed for numerous small studies for the benefit of both company and student. Multidisciplinary collaboration utilized the resources of the entire college campus bringing departments together in a research setting. The opportunity for students to further enhance their technical writing and presenting was important to their development. To further foster the development and career opportunities, industry recognized laboratory certifications were offered to the senior students. Faculty mentoring and guidance was made available to properly use the experience as a career builder and advancing knowledge as well as tackling real world problems. (Stier 1996) Students experience effective communication, action learning, problem solving and improved skills for the modern workplace. The end result can and will be higher level training of students to pursue advanced education and research careers. (Abudayyeh 2003)

Introduction

The need of integrating research into quality education has been reported in many technical journals, education reports, and college mission statements. The importance of "when and how" this experience is delivered became evident after evaluations from graduates and industry. Many traditional Engineering and Industrial majors introduce fundamental laboratory methods in the sophomore or junior year. This is essential for students to gain the understanding prior to their senior design courses. However, students were commenting on how they tended to lose sight of the basic testing procedures upon graduation. Likewise, students involved in undergraduate research were limited to faculty involvement with research. The opportunity for a student to oversee a research project was attractive to the student body based on the many benefits that the current undergraduate researchers expressed. Industry expressed an interest in having students better prepared for technical writing, reporting and communication.

The (CIM) program housed in the Engineering Technology and Industrial Studies (ETIS) department recognized the feedback from industry and students and decided to take an aggressive approach in fulfilling the research and laboratory need for undergraduates at all levels. In order to make this experience fruitful to all parties involved (students, faculty and industry), many entities and resources were sought out. This report outlines the many ways a research and laboratory experience can be gained by a student through multiple collaborative efforts, curriculum additions, and industry certifications.

Industry Collaboration

Local and regional industries have research needs that can not always be performed in house. This avenue is common for universities to step in and assist industry with research for the development of faculty and students. The projects can range from routine quality control to specialized research with specific instrumentation needs. The experiences that students obtain range from laboratory tasks, literature searches, data collection, site visits, publications, and presentations. The company benefits from the collaboration with recommendations and conclusions about the research while the student benefits seem endless. The course, *Senior Concrete Laboratory*, which was developed to foster these relationships, works well with industry needs. The applied research that is necessary for industry to be competitive was incorporated into semester long projects for the students. The first semester that the course was offered, students were divided into teams of one to four students depending upon the size of the project. The faculty professor was a mentor as well as an industry contact throughout the project. Meetings were set to discuss test plans and a schedule was formulated for the remainder of the project. Students were required to give progress updates to both the faculty and industry personnel. A final technical report was generated with a presentation given to the sponsoring company. MTSU also has an undergraduate research poster session at the end of each semester and all the students in the course were required to present their findings at the session. This allowed for younger students in the degree program to visualize what the senior expectations are as well as other departments to understand more about the CIM program.

Multidisciplinary Collaboration

Finding unique ways for a laboratory to be useful to more than just the students in the major is a challenge. However, it is both rewarding and beneficial to share a research lab as well as seek out other labs to become a part of. The opportunity then arises for collaboration among faculty and students in grant writing, equipment purchases, student exchanges, independent study, and multidisciplinary teaching and learning. The CIM program is housed in the Engineering Technology department which comes with many computer and material labs. To go outside this department offers many new equipment options. Relationships with chemistry, biology and geology have been forged with benefits to all parties involved. Equipment and supplies that once seem unique to a discipline become worth their weight in gold to another department seeking an answer. The students are able to come full circle with their laboratory experience when they visit and research in other labs. Therefore, the idea of multidisciplinary collaboration in the *Senior Concrete Laboratory* class was appropriate for students interested in crossing departments. The course allowed for students to work with other faculty and students in various departments during a research effort. The requirements for the course were still the same with the mentors being a faculty member from each department. Some examples of collaboration among departments are listed in Table 1.

Table 1.

Department	Project	Equipment
Biology	Calcium Hydroxide detection	Scanning Electron Microscope, Thermogravimetric Analysis
Chemistry	Fiber Surface	3D Scanner
Geology	Elemental Detection in Concrete	Multi Deflective XRay Fluorescent, Grinders, High Wattage Microwave

Technical Writing and Presentations

Industry had expressed the need for advanced training in research and technical expertise. Better communication in both the written and spoken word in research is essential. Students have exposure to writing technical lab reports in their sophomore laboratory so this model was used and expanded. Each week the students were introduced to an important section of a report and asked to start formulating their ideas and work into such a format. Then the students were given two weeks to complete a section of the report for review. Each team set a 20 minute meeting time with the faculty member to discuss the section in detail. The major areas of a technical report that were focused on were introduction and abstract, literature searches, research methodology, data collection and analysis, recommendations/conclusions and references cited. This accumulated to twelve weeks of discussion and review which left approximately three weeks for final edits. At the end of the semester, one class period was focused on possible avenues for publishing. Technical journals, trade magazines, seminars, and conferences were all options for students to pursue publishing with the faculty. Since the faculty member had invested a

semester into each team, the opportunity was there to publish work completed or leverage more research dollars into further investigation.

Certifications

The laboratory experiences that a student has become vivid recollections for future interviews, on-the-job scenarios and technical situations. The chance for a student to become validated by their hard work is important in a possible interview for an internship, co-op, or full time position. One way a student can truly benefit from the laboratory experience is to gain certifications in their respective field. It shows their knowledge base, their ability to be trained, and their dedication to the industry. Obtaining field and lab certifications can improve a student's chance of obtaining employment. There are numerous opportunities for 1-day seminars to 40 hour training that can result in specialized knowledge while still at the undergraduate level. A student feels a sense of accomplishment beyond the classroom and further insight into their career path. Incorporating the training in the curriculum allows for many students to benefit from the effort of the faculty. Some examples of certifications in the CIM program as well as the Engineering Technology and Industrial Studies department are listed in Table 2.

Table 2

.

Major	Certifications
Concrete Industry Management	ACI Level I Field Technician, ACI Flatwork Finishing Certification, ACI Lab Testing Technician, PCI Inspector Certification, Concrete Sales Professional Training
Occupational Health and Safety	Lead Abatement Certification, OSHA Training Certification
Industrial Management	Green Belt Six Sigma, Black Belt Six Sigma, Lean Manufacturing Training

All of these certifications listed are meshed into the curriculum to allow for students to take the opportunity to further succeed in their major.

Industry and Graduate Repsonse

This major degree program has approximately 65 graduates out in the workforce since its inception at MTSU in 1996. The CIM program also has relationships with approximately 200 companies nationwide with consistent feedback and interest into the program. The CIM graduates along with the top ranking officers in many of these companies get together once a year to decide on what is best for the current students and the changing needs of the industry. The plan of including Senior Concrete Laboratory as part of the curriculum, involving undergraduates in small research projects and integrating industry

certifications was a unanimous, well received decision. The benefit that the graduates saw were more exposure to the industry, a better understanding of quality control, advanced skills in technical reports, and getting back into a lab environment. The industry saw the benefit as a student ready to be a part of technical situations with fact finding skills and a quality control sense. A positive synergy is sparked between undergraduate teaching and research that is confirmed by responses from students and industry based on undergraduate research experiences (Sabatini 1997).

Conclusion

The experience that the CIM program has had with incorporating undergraduate research into the curriculum has been extremely positive and well supported. Industry has an academic collaborative partner with resources available for projects. Other departments on campus view our lab as a new untapped resource available for future collaboration. Industry certifications are becoming key elements to the curriculum to bring the hard work of the students and faculty to fruition. Students are now getting back into the laboratory prior to graduation to take part in this research effort while improving their technical skills. The advantages continue for a student beyond undergraduate level taking them into research careers, graduate studies and professional testing labs.

Works Cited

Abudayyeh, Osama, "Undergraduate Research Mentoring Model in Construction Engineering and Management", *Journal of Construction Engineering and Management*, Jan/Feb 2003, Vol. 129, No. 1 p65-69.

NSF Representative, "Curricular developments in the analytical sciences", NSF workshop 1996 and 1997.

Sabatini, David A., "Teaching and research synergism: the undergraduate research experience", *Journal of Professional Issues in Engineering Education and Practice*, July 1997 v123 n3 p98(5).

Stier, K.W., "Intergrating into Undergraduate Coursework to Provide Professional Experiences", *Journal of Construction Education* 1:18-28.

Biography

Brown, H.J.
Dr. Heather J. Brown is an Assistant Professor in the Department of Engineering Technology and Industrial Studies at Middle Tennessee State University (Murfreesboro, TN). Her research interests include many areas within concrete material science. She initiated the development of the new course along with fostering and overseeing the collaborations with industry and other departments. This effort assists in the academic achievement of her students as well as building relationships with industry through research.