AC 2010-1262: OPPORTUNITIES FOR STUDENTS AND FACULTY STEMMING FROM ENGINEERING TECHNOLOGY PROGRAM REFORM

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Opportunities for Students and Faculty Stemming from Engineering Technology Program Reform

Abstract

Burlington County College (BCC) is implementing the findings of an institution-level reform of its Engineering Technology programs in order to create meaningful job opportunities for displaced and incumbent workers, work-based activities and/or internships for students, and faculty development opportunities. In addition, the findings of this Engineering Technology program reform effort will be tailored to develop initiatives to increase enrollment in the Engineering Technology Programs, with special attention to under-represented students. The goal of this synergistic approach is to promote and improve discussion, collaboration, and the working relationship among interested stakeholders vested in the central/southern NJ manufacturing-related industry. This project has brought together a robust consortium made up of secondary schools, a community college, a four-year university, workforce development professionals, and industry leaders. The approach of cooperative interaction is expected to serve as a model for transforming a community college technical education program in an effort to create a seamless and meaningful educational and work-entry pathway for future engineering technologists and technicians. This project is based upon work supported by the Advanced Technological Education (ATE) program at the National Science Foundation (NSF) under Grant No. 0703836.

Introduction

The demand for highly-skilled manufacturing engineers and technicians is a growing concern in Burlington County and throughout New Jersey. Manufacturers in the state of New Jersey employ approximately 345,000 workers, 10% of the private sector workforce.[1] In Burlington County alone, over 20,500 people are employed by manufacturing companies.[2] Although some areas within the manufacturing sector have declined in recent years, there continues to be a strong demand for highly-specialized technicians who can bring critical technology skills to the manufacturing environment in order to affect operational efficiencies and cost reductions. For example, the New Jersey Department of Labor and Workforce Development (2004) projects[3] that demand for industrial engineering technicians (Associates degree holders) within Burlington County will continue to rise by 5.7% through 2012. Furthermore, statistical data from the US Census Bureau[4] (Local Employment Dynamics) indicates that in the first quarter of 2005, Burlington County had a total of 1,039 jobs created within the manufacturing sector. This figure represents 20% of the total number of manufacturing jobs created in New Jersey during that time period. Despite the growth within the advanced manufacturing sector, the demand for highly skilled technicians is exceeding the supply. According to the June 27, 2006 SHRM/Rutgers Leading Indicator of National Employment (LINE) report[5], 39.8% of the 500 manufacturers surveyed reported an increase in the number of vacant positions; a 7% increase from June 2005. The LINE analysts suggest that, “there is no longer a large pool of qualified job seekers eager to move into open positions.”

New Jersey employers and industry leaders have expressed their interest in working with higher education to overcome these employment challenges in an effort to increase the quantity and

quality of graduates that enter the workforce. A recent survey conducted by Rutgers University[6] found that 51% of NJ employers surveyed stated it was very or somewhat difficult to find well-prepared graduates from two-year colleges. Of these 400 NJ employers, 69% stated that more experience-based learning, such as internships, would improve higher education and better prepare students for employment. These employers also suggested "implementing ideas from business into college curriculums" and encouraged future collaboration with higher education so that "schools can become more familiar with their companies' skill needs."

More broadly, the National Association of Manufacturers, in its 2005 Skills Gap Report[7], identifies the skills gap in manufacturing as being extremely broad and deep, cutting across several industrial sectors. This shortage of qualified employees directly affects the ability of the US as a whole to compete in the global economy. Additionally, in a similar report[8], the Conference Board examines the basic knowledge of applied skills of workers and found that many of new entrants to the workforce lack skills essential to job success, skills that employers expect young people to already possess. This report particularly notes that employers surveyed see the educational system as primarily responsible for workforce readiness, and acknowledges the great role that parents play in instilling in their children the importance of learning, work, and career.

The needs of industry for skilled technologists

A one-day Planning Conference with some of New Jersey's manufacturing representatives was held in order to engage industry partners and learn from them their views regarding the most important skills for new engineering technology graduates to possess. New Jersey workforce development professionals, administrators, faculty, and students, from Burlington County College, the Burlington County Institute of Technology, Bordentown Regional High School, and Drexel University came together to identify and discuss the regional workforce needs and collaborate on plans to reform the Engineering Technology program. Specifically, attendees of the one-day workshop included over thirty industry professionals from sectors that ranged from automated pharmacies, to energy providers, to scientific and research organizations. Also in attendance were approximately twenty faculty and staff from Burlington County College and its partner institutions, along with six current and former BCC students. The participant input during the workshop, held in November 2007, paralleled the employer needs as described in several published reports for various regions and industries, which will be discussed.

Breakout sessions with 6-12 participants were held, in which a series of questions were asked and discussed in order to learn exactly what skills the industry representatives valued in newly hired graduates. While identifying these skills as being important, industry attendees also identified these important competencies as lacking in new employees to a significant degree. Questions discussed covered specific topical areas including: Technical Education Competencies, Employee Competencies and Training Needs, Future Trends, Partnerships, and Engineering Technology and Advanced Manufacturing Education.

Technical Skills

After compiling the results from the individual breakout sessions, it became clear that several common technical skills emerged as critical to various industries. These are skills that the industry representatives deemed highly valuable and required in the incumbent skill set of employees. Additionally, these are skills that are either currently being addressed in the present curriculum, or can easily be included in a future curriculum update. These technical skills included: computer network security, applied mathematics, statistical analysis, computer knowledge in both hardware and software systems, Microsoft Office skills, digital and control circuitries, computer control and automation, programmable logic controllers, project management, safety, hazardous material handling, understanding of specifications and technical documents, and English-to-metric conversions.

Elements of most of these skills are already present in BCC's Engineering Technology program to some degree and have various elements of assessment associated with them. Both the teaching and learning methods will be examined as part of the present project and adjusted appropriately, if required. Continuous feedback from industry participants, in the form of direct communication or surveys during the project will provide a vital mechanism to ensure updates are timely and meaningful.

Non-Technical Skills

In addition to the technical skills already mentioned, several common non-technical skills emerged as critical to most industries. These are skills that the industry representatives deemed highly valuable and required in the incumbent skill set of employees. Academic outcomes that are being used as benchmarks to measure these specific skills will be developed and the presence of these skills in BCC's curriculum will likewise be evaluated and updated.

The identified non-technical skills include: written communication, oral communication, presentation skills, teamwork skills, conflict resolution skills, ethics, professionalism in terms of attendance and employee responsibilities, problem solving skills and approaches, appreciation of the manufacturing process and procedure, customer support, appreciation of diversity, ability to set priorities, understanding of the business fundamentals, and creativity and innovation.

The importance of non-technical skills in a technical curriculum is something that has been considered by the Accreditation Board for Engineering and Technology (ABET), in both its Engineering Technology and Engineering accreditation standards. ABET currently requires non-technical skill sets that include: an ability to function effectively on teams; an ability to communicate effectively; a recognition of the need for, and an ability to engage in lifelong learning; an ability to understand professional, ethical and social responsibilities; a respect for diversity and a knowledge of contemporary professional, societal and global issues; and a commitment to quality, timeliness, and continuous improvement. Therefore, an ABET accredited engineering technology program should have criteria in place that will ensure graduates obtain a good foundation in these non-technical skills. BCC currently has two engineering technology programs accredited by the Technology Accreditation Commission of ABET.

Approaches cited in the literature outline methods by which institutions can meet the various non-technical course rigor requirements. One such effort involves the improvement of the writing skills of a group of undergraduate engineering students as presented by Yalvac *et al.*[9] Innovative educational methods such as role-play (a non-traditional technique for a technology education program) have been identified as helping improve difficult writing skills, such as argumentation and synthesis. Of particular importance cited by the authors is the necessity to facilitate any writing assignments in such a way as to allow students ample time to receive feedback, reflect on their learning, and appropriately revise their work. Another effort specifically focused on writing improvement by Grose[10] involves role-playing and debates as tools to sharpen student's writing abilities. In this study, writing is considered as a creative form of designing.

While educators are arguably more experienced in delivering pedagogy that relates to technical skills, and subsequently measuring the effectiveness through outcomes assessment, this approach is significantly less familiar for the non-technical skills. Shuman *et al.*[11] has addressed the issue and summarized recent work regarding both teaching and assessing these non-technical skills. Assessment, it should be noted, is of particular concern to educational institutions due to the more stringent requirements being placed on them by regional accrediting agencies, as well as by ABET. The authors point out that these non-technical skills can certainly be taught, though not necessarily in the traditional lecture format, as has already been alluded to. Assessment, however, is more difficult. Teamwork skills outcomes, for instance, may not be derived from performance in one particular class but rather from participation in several courses and several out-of-class activities over a period of time. Such a global approach to assessment will undoubtedly require more effort and tracking on the part of the educational institution, but if crafted correctly, can be expected to achieve higher level outcomes such as synthesis and evaluation according to Bloom's taxonomy.

Interestingly, professions other than engineering have identified the importance of non-technical skills in successful practice. For example, Yule *et al.*[12] have developed a rating system to assess and provide feedback regarding surgeons' non-technical skills. The authors point out that analysis of adverse events in surgery are often identified as having behavioral causes, such as poor communication, rather than technical causes. Technical skill is necessary, but not sufficient to maintain high levels of patient safety over time. The same can be said for Engineering Technologists and Engineers.

Opportunities for Students and Faculty

One outcome of the creative and innovative partnerships, such as those described in the current project, is to develop value-added opportunities for both students and faculty. These value-added opportunities can be created both within and outside of the academic institutions. The academic institutions considered include the community college, four-year university, and secondary schools that have participated.

Some of the specific value-added opportunities created as a result of the current project are outlined in the following sections.

Student Opportunities

Students benefit tremendously from the opportunity of being able to progress through a curriculum that is strongly aligned with the needs and requirements of their future academic institutions, as well as those of their eventual employers. Therefore, the relevance of a modified and improved curriculum, as through the program reform in the present project, cannot be overstated.

Internal Student Opportunities

Seamless Articulations

Programs that are sought out by students, and are therefore well populated, will be those that thoroughly prepare students for the next step in their academic journey, with no need for remediation or undue duplication of coverage. Close collaboration of institutions will ensure that students will progress seamlessly throughout the succession from secondary schools, to community colleges, to four-year universities. Such seamless articulations will ensure that student expense is kept to a minimum while gaining the most critical competencies in the shortest amount of time. A further result of this arrangement will be to minimize student debt in obtaining an education. Challenges to the creation of seamless articulations are not new, and have been well chronicled.[13] However, the recent explosion in enrollments, at community colleges in particular, necessitates the development of better transfer articulations for students.

Additionally, relevant academic programs that will turn out well-prepared students will be the ones that receive the available scarce resources and provide the most return to the academic institutions themselves. Program reform, then, will be a necessary requisite for program sustainability and will allow the creation of highly relevant academic programs that can easily compete among the many alternatives students have to choose from, including home schooling and distance learning programs.

Academic Advising

When program reform has been properly completed, the collaborative partnerships can yield highly effective academic advising outlines in which an interested student can be told exactly what academic trajectory they should follow. The opportunity for sound and transparent academic advising will allow a student to properly schedule their courses, semesters, and years in order to make the most efficient use of their time and financial resources. While the efficacy of academic advising has been studied and generalized, there have been studies that have sought to specifically measure the effectiveness of academic advising. One such study[14] has posited, for various student demographics, that academic advising is indeed actively beneficial to students' attainment.

Advanced Standing Credits

As a result of the close collaboration through program reform efforts, students may have the opportunity to earn advanced standing credit if the successive levels of academia are aligned to a high degree. For example, a high school student, who has been given proper guidance and advising, may place into an advanced computer aided drawing (CAD) class that may be eligible for college credit. The awarding of early college credit would allow the student to enter college

at the CAD II level. Such advanced standing arrangements will help a motivated student to maximize her or his efficiency while progressing through the academic ranks, as well as provide a large incentive for early achievement.

Additionally, early college high school programs, such as that established by the Bill & Melinda Gates Foundation[15], encourage students in under-represented demographic populations to earn college credits while in high school.

External Student Opportunities

Internship and Cooperative Education Opportunities

When advisory committee members have input and influence into the components of an academic program, they will naturally feel invested in such a program. Regional industrial partners are more likely to have confidence and interest in students who have progressed through academic programs that they themselves have helped to form and modify. Therefore, industry partners are more likely to give current students or graduates preferential consideration when there are available positions. Such available positions may include paid or for-credit internships, cooperative education experiences, or full-time employment positions. The benefits to students, from such academia-industrial relationships are many. For example, cooperative education experiences have been shown to have positive influences on grade point average, student retention, and starting salaries.[16]

The opportunity to learn skills and techniques that are timely, and that will add value to and employers operations, is another outcome of a valuable education that is difficult to overstate. Higher education institutions must constantly endeavor to impart meaningful skills to students, regardless of when a student takes leave of their academic pursuits and joins the ranks of working employees. In the current time of double-digit unemployment in many states, the ability of graduates to garner the interest of potential employers is critical.

Faculty Opportunities

Faculty will benefit from the opportunity of participating in collaborative program reform efforts in a variety of ways. Many of the benefits to faculty involve the ability to hone their skills and knowledge according to new and modern advances as well as to lend their existing expertise in their disciplines. Additionally, faculty benefits include stipends as incentives for participation in summer curriculum development workshops.

Internal Faculty Opportunities

Course and Curriculum Improvements

Faculty who participate in program reform efforts have the opportunity to contribute to, and take a leadership role in, the modification and development of new curricula. Curriculum development workshops allow faculty to express their professional judgments regarding the new directions academic programs may take in relation to their historical approach. Additionally, faculty have the opportunity to shepherd curriculum improvements through internal curriculum

review boards and provide insight to colleagues in all disciplines as to why proposed curriculum modifications are necessary.

Professional Development

The thoughtful and thorough review and improvement of curricula and programs allows faculty the opportunity to reflect on intended academic outcomes and goals. The collaboration with industry partners, the thorough review of alignment with industrial needs, and the close proximity to other academic colleagues all set the stage for meaningful professional development opportunities. With proper administrative support, an academic faculty's efforts regarding program reform can serve as meaningful professional development activities. Such meaningful professional development opportunities can help to provide faculty with innovative and challenging ways to keep their teaching engaging and relevant.[17]

Laboratory and Equipment Improvements

Faculty who engage in comprehensive program review have the opportunity to collaborate with industrial partners who likely have more immediate access to the latest equipment and technologies. Staying closely connected with industry advancements will allow academic faculty to closely monitor the need to update equipment and laboratory modules, for example.

External Faculty Opportunities

Residency Opportunities

Faculty who participate in program reform that is deeply rooted in industry collaboration can possibly have the opportunity to visit and experience some element of residency at the industrial partners sites, when a close relationship exists. Many industry partners are willing to allow faculty to observe and consult regarding their facilities and operations. Industry participants generally know the value that a discipline expert can lend to an industrial operation. Additionally, mentoring opportunities between faculty and industry partners is possible.

Best Practices and Lessons Learned

Throughout the course of this project, several best practices have come to light that have helped to ensure that the engineering technology curriculum includes the necessary skills and competencies that are needed by industry.

First among the best practices was the necessity to achieve buy-in from all participants. This entailed first gaining industry participant's interest and commitment to attend events and share their requirements, which served to stimulate the entire effort. Without strong industry interest and commitment, the later activities would have been extremely difficult. Secondly, the approach to modifying the engineering curriculum must include multidisciplinary faculty, i.e. faculty from scientific and technology disciplines as well as from liberal arts disciplines such as English, Sociology, and Psychology. For example, when discussions regarding technical communication arose during the summer curriculum development workshop, it was critical to have English faculty participate. Without this multidisciplinary inclusion, any curriculum reform effort would be stifled.

Finally, workgroups formed during the summer curriculum development workshop were allowed to work in parallel, without exclusion of topics or overlap. This parallel approach allowed the group presentations to include some common elements, which then served to reinforce several key findings. However, differences in the workgroup findings and suggestions were sufficient enough to add to the body of curriculum improvements and reforms.

Next Steps

Resources are being pursued to address and implement many of the proposed recruitment strategies, especially targeting underrepresented student populations. These strategies will be developed to increase the quantity and diversity of BCC Engineering Technology graduates. To recruit, train, and retain underrepresented populations, relationships with professional organizations such as the Society of Women Engineers and the Society of Hispanic Engineers will be cultivated and incorporated into the program.

Faculty professional development opportunities for both secondary and college faculty, as well as work-based activities for students, are being developed via current relationships with industrial advisory committees. Additionally, customized training opportunities for incumbent and displaced workers who may have already graduated from either an Associates or Baccalaureate degree program, incorporating the identified technical and non-technical skills are currently in development. Such professional certification programs will give college-degree holders an opportunity to retool and retrain in vital areas in which they seek employment. Such areas include technical writing and computer control and automation (programmable logic controllers), for example.

Summary

The activities of the NSF-supported project regarding an institution-level reform of an Engineering Technology program, and opportunities for both students and faculty, are described in this paper. Specifically, this project is supported by the Advanced Technological Education (ATE) program, Phase 1. With an emphasis on two-year colleges, the ATE program promotes partnerships between two-year colleges, four-year colleges and universities, secondary schools, business, industry, and government. These partnerships and curriculum development efforts are supported by the NSF in order to provide the academic experiences needed to successfully recruit students and prepare graduates for the high-technology fields that drive our nation's economy. The ATE program supports several critical activities including: curriculum development, professional development of college faculty and secondary school teachers, and the creation of seamless pathways to two-year colleges from secondary schools as well as from two-year colleges to four-year institutions. The results of this project will form the basis of a Phase 2 proposal submission.

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