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Institutional-Level Reform of an Engineering Technology Program

Abstract

Burlington County College (BCC) is completing an institution-level reform of its Engineering Technology Associates degree program in an effort to better meet the workforce demands of industry in central New Jersey. This project brings together a 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. One of the main goals of this project is to strengthen the ties within the technical education community and promote industry participation in educating students and training technicians. The addressed topics include: (1) transforming the Engineering Technology curricula to better meet the technical standards of industry; (2) developing customized training opportunities for incumbent and displaced workers; (3) integrating work-based activities and/or internship programs for students in the educational process; (4) developing initiatives to increase enrollment in the Engineering Technology Programs, particularly of under-represented students; (5) enhancing faculty development opportunities with local industry partners; and (6) promoting discussion, collaboration, and a working relationship among interested industrial stakeholders vested in the tri-state (NJ, PA, and DE) area. This project is 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) [3] projects 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 will be 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.

The efforts to reform and update the Engineering Technology Program in the current project will certainly contain elements of assessment in order to demonstrate that the critically identified non-technical skills are appropriately mastered by students.

Program Analysis and Development

After identification of the most critical technical and non-technical skills from industry participants in the one-day planning conference, the goals of the subsequent week-long summer workshop were drafted. In this week-long workshop, a multi-disciplined (with both STEM and liberal arts expertise) and multi-segmented (with both secondary school and college faculty) approach was taken toward analysis of BCC's engineering technology programs, for inclusion of the previously identified critical skills. BCC's engineering technology program offerings were critically examined for alignment with the identified technical and non-technical skill sets.

Over twenty educators were assigned to one of four workgroups to examine and develop several aspects of BCC's engineering technology programs through analysis and discussion of topics which included:

i) Prioritization of the critical skills identified by industry

ii) Identification of new skills that may be added to the curriculum

iii) Development of recruitment strategies for underrepresented populations

iv) Proposal of work-based activities for students

v) Proposal of faculty development opportunities

The main approach of the weeklong workshop involved analyzing and incorporating into the engineering technology programs the identified critical course and program competencies. Tools developed and available for the workshop included published material such as course descriptions and outlines, program review documents, college catalogs, textbooks and other supplemental material, and a webboard. The webboard proved especially useful in facilitating the exchange of information to and among individual workgroups.

At the end of the workshop, each workgroup presented a summary of their discussions and findings related to the above-listed topics. The summary presentations brought to light some common approaches among the groups as well as some unique and insightful possibilities for program reform.

A compilation of the workgroup findings and suggestions are presented in the table below.

Topic	Findings and Suggestions
Prioritization of the critical skills identified by industry	**Technical** •computer skills (both hardware and software) •project management •safety **Non-Technical** •written communication •customer support •ability to prioritize •conflict resolution •creativity and innovation

Identification of new skills that may be added to the curriculum	•Technical writing as a program requirement; administer a proctored technical writing assessment during final exam week that will be required of all students (given a hypothetical or real-world data set) •Public speaking as a requirement •A one credit seminar to help students set priorities, develop study skills, etc. •Programmable logic controllers •Statistical analysis •Understanding of business fundamentals
Development of recruitment strategies for underrepresented populations	•Establish a buddy system with a high school student paired with a BCC student; which would include visits to campus •Give interested high school students a BCC email address, for communications regarding technology programs and other academic concerns •Develop relationships with individual teachers and guidance counselors to speak on behalf of BCC to the local PTA and parents •Create DVD's and web stream profiles of recent successful graduates as ambassadors; maintain and strengthen program alumni relationships; highlight local student accomplishments in newspapers, newsletters, etc. •Utilize a sports recruitment model: personally contact individuals and target specific students identified by high school teachers; include parents •Share information about scholarships and innovative partnerships with graduating eighth graders •Develop a for-credit Co-op program at BCC •Reach large groups of high school freshmen in orientation sessions and highlight 4-year college partnerships at BCC •Provide transportation to BCC's campuses for secondary school students to experience the advanced laboratories and facilities •Produce videos to specifically address the concerns and interests of secondary school teachers, counselors, and parents •Waive application fees and offer tuition discounts for students who complete a one credit college orientation course •Create relationships with church groups and youth groups

Proposal of work-based activities for students	•Develop opportunities to work on real-world projects provided by local businesses •Create summer internship opportunities, provided by advisory committee members, which would include high school students •Develop technology career development workshops specifically for technology students
Proposal of faculty development opportunities	•Create opportunities for faculty to teach at other institutions, perhaps on an exchange basis •Create opportunities for full and part-time faculty to meet to discuss program requirements and teaching techniques •Bring STEM teachers from area high schools and middle schools (or web conference) to experience BCC's facilities; and allow accrual toward professional development hour requirements •Develop job shadowing opportunities for faculty with industry professionals •Allow sufficient time and flexible dates for high school faculty visits to BCC

Student Outcomes Assessments

In order to properly judge that students have obtained the necessary level of competency in each of the identified technical and non-technical skill areas, by utilizing the findings and suggestions above, specific and measurable outcomes will be defined using Bloom's taxonomy. Where possible, an external means of assessment will be coupled with an internal means to effectively measure that students have reached a high level of competency in each identified critical skill.

Best Practices and Lessons Learned

Throughout the course of this project, several best practices have come to light that helped to facilitate the goals of examining curriculum and suggesting modifications to achieve the intended skills and competencies 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 be extremely difficult. Secondly, the approach to modify the engineering curriculum must include multidisciplinary faculty, i.e. faculty from scientific and technology disciplines as well as 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

After having identified several critical skills of interest to regional industry participants, and having a multi-segmented, multi-disciplinary faculty examine academic programs and make suggestions for improvement in delivering the needed competencies, much work remains.
Already underway is the implementation of several program reform suggestions, such as the inclusion of a public speaking course as a general education requirement. Additionally, steps are currently being taken to update a technical writing course and allow engineering technology students to take this course as part of their written communication requirement, in place of English Composition II. This course should also be accepted by 4-year college partners upon student transfer. In all course modifications and improvements, student learning outcomes will be developed to align with industry expectations and thus will likely include work-based activities in the educational process. Thus pedagogy will be further developed to both teach the critically identified skills and assess that students have indeed gained a high degree of competency in each one.

Additionally, resources are being assigned 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 curriculum, perhaps by the creation of student chapters, for example. Burlington County College is uniquely positioned to meet the needs of underrepresented student populations with its outstanding laboratories, facilities, and partnerships and future students need to know by the eighth grade (possibly sooner) what educational opportunities are available in their home county.

Faculty professional development opportunities for both secondary and college faculty, as well as work-based activities for students, will be immediately pursued 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 will 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 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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