Secondary and Post-Secondary Partnering – Enhancing the Pre-Engineering Curriculum

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Abstract: This paper describes a project involving a major research university, New Jersey Institute of Technology, and thirteen secondary and post-secondary New Jersey schools to develop and implement a career cluster program for the Research, Development and Technical Services career major. This Engineering Science Technology Tech-Prep grant, sponsored by the New Jersey Department of Education, has three main career goals for this project. These goals include preparing a skilled workforce that meets industry and educational standards in the fields of engineering, science and technology, establishing a consortium to improve training opportunities for students, and improving and expanding articulation between the secondary and postsecondary providers of education and training. This grant is based on a five-year development cycle, where career clusters will be developed for a wide spectrum of engineering disciplines.

The creation and implementation of this project based curriculum and the establishment of linkages between secondary occupational education programs and postsecondary programs leading to degree programs will be discussed.

Keywords: secondary education, skill sets, career clusters

Introduction

With a population of over eight million, New Jersey has a very diverse technological industrial base. It is the corporate home of such companies as AT&T, Lucent Technologies, Johnson and Johnson, Becton Dickinson & Company and Warner Lambert. To help fulfill an economic need for qualified people seeking career opportunities in the state's R&D industry, a program was established to develop a pool of academically prepared, technically sophisticated youth.

This program was sponsored by a grant from the New Jersey Department of Education, starting in September 1998. Its purpose was to develop a local consortium of comprehensive schools, county vocational schools, two-year colleges, four-year colleges and research universities, and the R&D industrial base to ensure the New Jersey's youth are adequately prepared for entrance into two-year and four-year engineering, science and technology degree programs. The ultimate goal was to prepare these students for careers in research and development industry, using an articulated curriculum, grades 11 (high school) through junior year (college).

This grant is based on a five-year development cycle, where career clusters will be developed for over ten disciplines within engineering, science and technology. Each year, there is a focus on one of these major career clusters and Table 1 lists the time for these career clusters.

Table 1. Timetable for career clusters

Year One	Mechanical engineering, physics and technology
Year Two	Chemical engineering, chemistry, environmental science and technology
Year Three	Electrical and computer engineering, computer science and technology
Year Four	Civil engineering, material science and technology
Year Five	Engineering life sciences, including biomedical and biotechnical engineering, biology and technology

This paper describes the results of the first two years of this grant, including the establishment of skill levels for the specific disciplines, linkages between the educational and industrial partners and project based learning modules.

Project Participants

School participation was restricted to schools that had an approved engineering/pre-engineering Classification of Instructional Program (CIP) code, which is part of the New Jersey Department of Education classification of high school programs. The two major participants in this grant are Bergen County Academy and New Jersey Institute of Technology.

Bergen County Academy incorporates The Academy for the Advancement of Science and Technology and The Academy for Engineering and Design Technologies. These two academies are public magnet schools for science and technology located in Bergen County, NJ. NJIT is one of only three designated public research universities in the state of New Jersey and ranks among the leading engineering/technology research universities in the United States. In addition to the twelve other educational partners within New Jersey, there are over twenty New Jersey based industrial partners, including many of the major New Jersey based corporations.

The other secondary school participants in this grant include: Gloucester County Institute of Technology, Middlesex County Vo-Tech, Monmouth County Vo-Tech, Morris County School of Technology, Newark Public Schools, and Union County Vo-Tech. Because these graduates can articulate to a two-year community college program, four community colleges were included as educational partners. These schools are Essex County College, Gloucester County College, County College of Morris, and Union County College.

Coordination with industry is one of the key factors in developing successful educational programs. In addition to the educational partners, there were twenty industrial partners, representing many of the major industrial corporations within New Jersey, such as Lucent Technologies, Allied Signal Corporation and Becton Dickinson & Company. Another part of the industrial linkage were representatives from the Research & Development Council of New Jersey, which is a non-profit association representing over 50 major New Jersey companies. The purpose of this organization is to creating a strong, healthy environment for the continued growth of R&D within the state of New Jersey. Its responsibility under the grant includes a mentoring program for representatives of the educational partners and cultivating internship sites for students at the representative high schools.

Skill Set Lists

New Jersey Institute of Technology developed a skill set list, to be used as a foundation for engineering study. The skills were identified in the areas of mathematics, science, engineering principles, design, technology and communications (written and oral). The skill set list also included "soft skills" such as the ability to organize projects, work in groups and meet deadlines within a team format. Table 2 list the skill sets categories and subcategories developed for the first year.

As an example of the detail within each category, the category Dynamics included the following skill sets: Effect of gravity, particle dynamics, motion around a curve, projectiles, mention of Newton's first, second and third laws, history of Sir Isaac Newton and his theories, and introduction to force systems. An example of the detail within a "soft skills" category, the category Writing included the following: Spelling or knowledge of 'spellchecker', grammar and writing in complete sentences, order of information, table of contents, how to write an abstract, and ability to write a lab progress in a journal.

Table 2. Skill sets categories and subcategories

Main Category	**Sub-Category**
Math	Algebra
	Graphing
	Geometry
	Trigonometry
	Calculus (desired, but not required)
Physics	Time and motion relations
Dynamics	
Communication skills	Reading
	Speaking
	Writing
Problem Solving Skills	
Computer Knowledge	Windows environment
	File Management
	Use of the Internet

While the first year represented the development of specific career clusters for Mechanical Engineering and Physics, the development of these skills sets have proven to be general in nature. There were only 8 skill sets that were modified for the second year, when the Chemical and Environmental Science and Engineering/Chemistry career cluster was developed, since most of the skill set categories crosses multi-disciplines within engineering, science and technology. Each of the partner schools was given this skill set, and the creation of a particular project would involve marking the specific skills that were covered. The individual projects would cover a small fraction of the entire skill set list, but when there were sufficient projects available from the educational partners, all skill sets should be linked to one or more projects.

The industrial partners for this grant reviewed these skill sets, and a curriculum project template, developed by Bergen Academy faculty, facilitated establishing a relationship between these skill sets and the New Jersey Core Curriculum Content Standards. These Core curriculum content standards were an attempt by the state to define the meaning of "Thorough" in the context of the 1875 New Jersey State constitutional that guarantees that students would be educated within a Thorough and Efficient system of free public schools. These standards ensure that all children receive a "T&E" education despite the fact that in New Jersey there are approximately 600 independent school districts that exercise considerable "local control" over curriculum. These standards describe what all students should know and be able to do upon completion of a thirteen-year public education. Table 3 illustrates an example of this relationship.

Project based learning

The URL http://www.bergen.org/EST/Projects/Can_2/Introduction.html, which is part of the overall Tech-Prep website, shows an example of project that NJIT and Bergen Academy developed for this grant. This project was divided into six activities involving the use of a custom can crusher to illustrate several of the skill sets previously described. The six activities included simulating the can crusher, data collection, computer simulation, building the

unit, an advanced activity upgrading this unit, and finally finding an electrical equivalence for the slider-crank mechanism.

There is a student page, which has a link to a website describing the process of recycling, as well as a link to the McAllen International Museum website showing the use of recycled aluminum for furniture. The teacher page describes the goals of this project, which is to have students work in groups to apply the physics, mathematics and 'human' data to solve a real world engineering problem. The theory of the slider-crank mechanism was introduced in the context of torque and rotational motion, and this mechanism's use in real world applications as an internal combustion engine (e.g. cars, lawnmower, motorcycles etc.) and pumps was shown on this website.

The activities in this project were then related to the New Jersey Core Curriculum Content Standards. An example of this relationship, for the Mathematical category, can be seen in Table 3. This table represents only a few of the Core Curriculum Standards for the mathematical activities

Table 3. A relationship of the New Jersey Core Curriculum Content Standards and the mathematical activities of the Can Crusher Project.

New Jersey Core Curriculum Content Standards	Activities from Can Crusher Project
Standard 4.1 (cumulative Progress H.S.): Use discovery-oriented, inquiry-based, and problem-centered approaches to investigate and understand the mathematical content appropriate to the high school grades.	Geometry and basic calculus is required for the measurement of the force calculations in activity 1 (see Mathematical concepts).
Standard 4.1 (cumulative Progress H.S.): Recognize, formulate, and solve problems arising from mathematical situations, everyday experiences, applications to other disciplines, and career applications.	The can crusher project is designed to fulfill this standard by translating mathematical formulation into the creation of a mechanical device.
Standard 4.3: All Students Will Connect Mathematics To Other Learning By Understanding The Interrelationships Of Mathematical Ideas And The Roles That Mathematics And Mathematical Modeling Play In Other Disciplines And In Life.	Math is used in the project in conjunction with Physics and Mechanical Engineering. It is used as an essential step for design and simulating the product.
Standard 4.7: All Students Will Develop Spatial Sense And An Ability To Use Geometric Properties And Relationships To Solve Problems In Mathematics And In Everyday Life.	Geometry is used in order to understand the slider-crank mechanism and calculate the force needed for performing the crushing (see Slider Crank Geometry).

Another project with similar linkages to the Core Curriculum Content Standards is the Optics project, where students learn to measure and predict stresses in mechanical parts and structures.

Articulation agreements

There is a difference in the type and levels of pre-engineering programming currently in operation at various secondary school sites. Some schools were ready for advanced project development, while others were more interested in basic curriculum and alignment work. Thus, there was a need to look at curriculum from several viewpoints, and from the perspective of several different career ladder goals.

The development and/or revision of articulation agreements between the community colleges and the participating high schools, community colleges and New Jersey Institute of Technology and between the participating high schools and New Jersey Institute of Technology are an integral part of this program. NJIT has worked with two of the educational partners, Monmouth County Vocational Schools and Union County Magnet School, to review such items as curriculum, student subject matter performance levels, the degree to which students demonstrate an ability to work on projects and on teams, teacher qualifications and teacher methodologies. In addition, NJIT has negotiated two agreements with the community college educational partners – Union County College and Raritan Valley Community College – for their Associate Degree in Science.

NJIT also has an agreement with the Academy for Engineering and Design Technologies (AEDT), enabling students to have advanced standing (sophomore year status) upon their enrollment in NJIT. The advanced standing is dependent upon completion of an articulated curriculum (the model for this project) which was developed by the faculties of NJIT and AEDT, students graduating from AEDT with a GPA of B or better, and success on NJIT's placement tests. This agreement is currently being implemented, as the first class has been admitted for Fall 2000, and it will subsequently be evaluated for application to other magnet high schools.

Conclusion

An overview of a project entitled Engineering Science Technology Tech-Prep grant, designed to develop and implement a career cluster program for the Research, Development and Technical Services career major, has been presented. The program will be consistent with industry expectations for new workers and will define the educational standards required for successful postsecondary study and entry into career positions, through the use of project based curricula, articulation agreements and coordination with industrial partners. By the end of the fifth year of this project, all the major engineering and science career clusters will have been completed.

Bibliography

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