STRATEGIC ALLIANCES WITH INDUSTRY TO ENHANCE THE UNDERGRADUATE SCIENCE, MATHEMATICS AND ENGINEERING EDUCATION

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Abstract *- Industry partners are important stakeholders for the College of Engineering at the University of Puerto Rico at Mayagüez Campus (UPRM). They not only play an important role in curriculum revitalization but also provide important feedback on the skills, values and competencies our graduates possess upon graduation. This paper summarizes two curriculum innovation programs implemented at UPRM, the NSF-sponsored Learning and the NASA-sponsored Partnership for Spatial and Computational Research (PaSCoR) Both of these programs aim to strengthen academic programs through innovative teaching/learning concepts such as hands-on activities, real-life projects, active learning, and summer internships. As a result graduates are knowledgeable in specific areas of science and technology, and possess the skills necessary to enter graduate school and/or professional occupations. Strategic alliance with industry has also allowed the College of Engineering plan and implement an outcomes assessment strategy to achieve accreditation of all its programs under the new criteria, known as EC 2000. Details of the interaction and collaborations are included.*

Index Terms – curriculum development, industry collaboration, ABET EC 2000

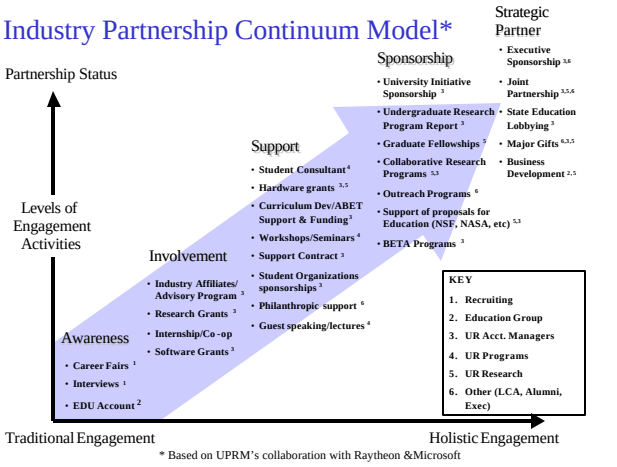
INTRODUCTION

Industry – academia collaborations can result in multiple benefits for all parties participating in joint projects. Projects may range from very specific, to broader, well-planned institution-wide joint business ventures. Figure 1 presents the industry partnership continuum model based on existing collaborations with Raytheon and Microsoft that the College of Engineering of the University of Puerto Rico at Mayagüez (UPRM) maintains. UPRM has learned that the following

Figure 1. The Partnership Continuum

elements are essential in developing a successful collaboration and relationships with industry. The following represent key success factors in the implementation of successful collaborative initiatives with industry:

- ***Development and nurturing of a Strategic Plan.*** Having a strategic plan in place allows all of those involved to understand and work toward common goals



* Based on UPRM's collaboration with Raytheon &Microsoft

and their mutual interests. All involved parties must then be prepared to reassess and revise their goals and strategies regularly.

- ***Establishment of clear individual and common goals and expectations.*** Both industry and academia must have an understanding of what is to be expected from one another, whether it's recruitment of top students or partnership roles in a specific research and development project, or business venture.
- ***Understanding of the organizational culture of each partner***: Each partner must understand how the other conducts business and their specific needs. For example, response time in an industrial environment is quicker than in a university environment. Also, university faculty tends to work alone rather than in team-oriented environment which is common to industry.
- ***Identification of "champions" and assignment of contact person(s).*** Both organizations have to identify people who believe in the partnership and are willing to

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put the time and effort to make it a successful venture. By assigning a contact person(s) for each organization, continuity and clarity of the status of the collaboration are maintained and trust is developed among the various parties.

- ***Involvement at all levels.*** Involvement at all levels in both organizations in the partnership is extremely critical. This will guarantee financial and programmatic support over the long term.
- ***Multiple and diverse collaborative activities.*** Having multiple, diverse collaborative activities will maintain and enhance relationships between all partners. These collaborative activities may include internships (both for students and faculty), faculty professional development grants for equipment, joint workshops, and dialogues about education issues and research and development areas.
- ***Development of trust through meetings and participation in activities.***

This paper describes the three programs and the role of industry has played in enhancing our education endeavors, through collaborative efforts with the University.

THREE PARTNERSHIP EXAMPLES

Learning Factory: With the assistance of industry, the University of Puerto Rico at Mayagüez has established two important programs that respond to the needs of society: 1) The ***Learning Factory*** [4] and 2) the ***Partnership for Spatial and Computational Research (PaSCoR)*** [3]. The Learning Factory is a program implemented by the Manufacturing Engineering Education Partnership (sponsored by the U. S. National Science Foundation (NSF)) to develop a product realization and manufacturing option in collaboration with industry partners that uses specially designed laboratory facilities. Three major universities with strong engineering programs (Penn State, University of Washington and University of Puerto Rico at Mayagüez); Sandia National Laboratory; over 100 industrial partners, and the ARPA Technology Reinvestment Program which provided federal government funding for the program. The overall outcome of the program was the development of the Learning Factory, a new, practice-based curriculum and physical facilities for product realization and manufacturing. The major goal of the Learning Factory program was to provide an improved educational experience that emphasizes the interdependency of manufacturing and design in a business environment, thus graduating better engineering professionals exhibiting the knowledge and skills needed to succeed in a highly competitive corporate or educational environment. The desired skills that students develop include communication, teaming, business skills and project management. The key element in this approach is *active learning*: the combination of curriculum revitalization coordinated with *hands-on experiences*. Thus, the gap is reduced between traditional lectures vs. laboratory, academia vs. industrial experiences.

The *Learning Factory's* major goals are (1) the development of a practice-based curriculum and the equipment and physical facilities needed to teach students about product realization and manufacturing, and (2) the graduation of outstanding engineering students who possess the knowledge and skills needed by industry so that they can succeed in the highly competitive world of today and tomorrow. These goals have been achieved through four major tasks, as described below.

- Curriculum development: Develop a practice-based undergraduate engineering curriculum that balances analytical and theoretical knowledge with product realization and manufacturing, design, business issues, and professional skills.
- Integration of *Learning Factory*: Develop a Learning Factory at each partner institution, integrated with curriculum to provide facilities for hands-on experience in design, manufacturing and product realization.
- Collaboration with industrial partners: Develop strong collaboration with industry and relationships with industry that will be sustained over the long term.
- Outreach with others: Share the project's products with other academic institutions, government and industry partners.

This program offers a new paradigm for engineering education, providing a balance between theory and practice. The students learn by performing nontraditional educational activities integrated into the curriculum. For example, in the capstone design course students work in teams to dissect a product, then engineering professionals are brought to the classroom and real-life problems are solved. The syllabus of each course not only includes the curriculum knowledge-base the student is required to learn, but also opportunities to develop skills in communication, teamwork, business issues, and project management. More than 100 corporate partners covering a wide spectrum of United States industries and government agencies in addition to more than 40 faculty members from 3 academic institutions, teamed for 3 years to achieve the Learning Factory goals.

PaSCoR: The ***Partnership for Spatial and Computational Research (PaSCoR)*** is a program to develop an interdisciplinary remote sensing and geographical information systems (RS-GIS) option that integrates undergraduate research in various undergraduate science, mathematics and engineering technology programs (sponsored by the U.S. National Aeronautics and Space Administration through Grant No.NCC5-340). The main goal of this 5-year grant is to strengthen academic programs and integrate research in various science, math, engineering and technology (SMET) disciplines at the undergraduate

level. The PaSCoR program initiated in 1998 (?) follows the strategy of the *Learning Factory* model, initiated in 1998 by the Manufacturing Engineering Education Partnership [3].

The PaSCoR program is being developed in response to the need for skilled scientists and engineers in the areas of remote sensing and geographic information systems (RS-GIS). It is outcome-based and student-centered, incorporating undergraduate research and hands-on activities throughout the student's academic career. The goal of the program is to produce graduates who are knowledgeable in the RS-GIS technology and applications and possess the necessary skills to enter graduate school or become a successful professional in those areas.

PaSCoR offers an "alternative track" or "option" for undergraduate SMET students in the areas of RS-GIS, global positioning systems, data visualization, animation and analysis, and other related topics. This track or option will provide the student with nontraditional learning experiences in the new courses to be developed and those to be revised in four SMET programs (Electrical Engineering, Geology, Mathematics and Agricultural Sciences). It is hoped that this "alternative track" will help attract and retain students and provide a focus for preparing students for careers and graduate studies in these areas. This innovative program integrates an undergraduate curriculum with hands-on experience provided by exposure to laboratory activities and undergraduate research that spans the student's college years, ending with an internship in an industrial or a government laboratory site. The key element in this approach is the combination of curriculum revitalization with coordinated opportunities for application and hands-on activities. The courses to be developed and those to be revised will contain and balance contents with "soft skills" such as problem solving, communication and teamwork. The students completing the course and research requirements will receive a certificate in RS-GIS. In this manner, the University also is addressing issues brought forth by the new engineering education accreditation criteria known as ABET 2000 (Accreditation Board for Engineering and Technology Criteria 2000). These criteria require the establishment and publication of the student outcomes and a process of continuous assessment for process enhancement.

PaSCoR and *Learning Factory* programs aim at developing values such as diversity, teamwork, global awareness, and communication. Industry is a critical stakeholder in developing and instituting these programs.

ABET Accreditation: Industry partners are currently providing critical support in the College of Engineering accreditation preparation process under the new Accreditation Board Engineering and Technology (ABET) criteria, known as EC 2000. Our industry partners for all engineering departments are providing valuable feedback on graduates skills, competencies and values by donating their time, services and resources through Industry Advisory Boards. At the College's level, three companies, Raytheon Microsoft and Hewlett Packard have been very instrumental in providing support of the College's overall strategic plan for achieving ABET EC 2000 accreditation. For example, Raytheon and Microsoft facilitated a 2-day faculty ABET EC2000 Retreat that helped kick-off and energize the College of Engineering to develop its strategic plan to prepare for the new ABET 2000 Criteria. The retreat goals were to tie each UPR-M College of Engineering College mission and vision to the institution's mission and vision, to establish a link between each department's educational objectives and program outcomes, to develop each department's strategic and action plans to ABET EC 2000 accreditation and to prepare for a Raytheon team-sponsored mock visit in Fall 2001. The outcomes from the retreat are assisting each department in the college to prepare for their visit in the Fall of 2002. Another company, Kimberly Clark, has agreed to offer "train the trainer" workshops in areas such as leadership, global awareness, and defining and evaluating skills to help ABET teams and faculty design modules in these areas as well as develop assessment instruments to measure a-k skills.

Additionally, Hewlett Packard has donated equipment for database development and data collection software and project management for the college. The continuous program and student outcomes strategy is being designed using Microsoft Project Central. The approach that we are proposing is to integrate the ABET self-study document and the master project plan in Microsoft's Project Central. All ABET coordinators and users will have access to the self-study forms in order to complete it and use it for continuous annual program evaluation. A central database will be created for such purposes.

ROLE OF PARTNERS

To achieve the expected curriculum outcomes, it is of utmost importance that industry and other partners become major stakeholders in the program. Their role in the educational paradigm is vital; therefore, Industrial Advisory Boards were created for both programs. These boards are composed of respected industry representatives from local, national and multinational organizations and institutions.

The Boards play a role in:

- Providing input and critique to our curriculum,
- Providing students projects,
- Assisting in the evaluation of student projects,
- Providing experts for lectures, seminars and workshops,
- Providing summer internships for faculty and students, and
- Providing full-time jobs for our graduates.

Figure 2. PaSCoR Advisory Board Meeting

To place as many students in summer internships and to secure student projects and other resources, these Boards also provide assistance in preparing and implementing memoranda of understanding (MOU) with various local and national institutions. Some collaborators include: Microsoft, Raytheon, the U.S. Geological Survey, Trimble, Caribbean Pictometry, Inc. and the NASA Stennis Laboratory.

CONCLUSION

Over the past several years, the trend has been that academia and industry develop a holistic relationship that expands the continuum in engineering education and corporate related University Relations programs. That is, when academic and industry have common goals and mutual interests, successful partnerships can generate excellent results.

The primary reward is to graduate students who are well prepared for professional work. Other ancillary rewards to academia can include additional funds for research and development through grants from funding institutions, recruitment of additional students and faculty, new workshops and seminars and business ventures. The rewards for industry include reduce cost in training, coordinated research to support product line development, business ventures collaboration and partnership with federal government agencies and other corporations, faculty and curriculum development and the ultimate benefit of developing long-term science, mathematics, engineering and technology pipeline and pathway development for America to improve its competitive advantage. However, the success of the collaboration and relationship occurs only if there is trust and continuous fostering by key individuals at each organization.

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