International Applications for Project Integrated Learning through Engagement in the Partnership for the Advancement of Collaborative Engineering Education (PACE)

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New Title:
Global Applications for Project Integrated Learning through Engagement in a Global University-Industry Partnership

Introduction

Understanding what it takes to get students to succeed in science, engineering, technology, or mathematics is a nationwide concern. Adding to this concern is the trend of STEM becoming inherently more multidisciplinary and skillfully diversified. Industry demands graduates to be prepared not only with depth and breadth of disciplinary knowledge but with the skills, attitudes, and strong self-efficacy beliefs necessary for the workplace. Concerns about the success of STEM students, particularly women and minorities, present an urgent need to improve STEM educational programs. The challenge is to create educational environments that foster comprehensive training that includes meaningful connections to the real world of work, while facilitating the development of self-efficacy beliefs and soft skills all leading to the competency necessary for the job market and employers' expectations (Harris, J. G, et al, 2013). As stated by Clark (2012), higher education must enhance the employability and work readiness of its graduates by helping the students to transfer the knowledge gained in the classrooms into situations in the labor market (Clark, S. 2012). Employability has been recognized as a lifelong process that supports students' development of knowledge, skills, attitudes and behaviors which will enable them to be successful not just in employment but in life generally. To address this, experiential learning can be used to provide opportunities of active participation in real working environments where the students accumulate knowledge based on learning environments (Hedin, N., 2012). The literature consistently reports that experiential learning sets the foundation of educational environments where students can gain professional experience while applying the knowledge learned in class (Andrews, 2008). The andragogical value of experiential learning relies on its ability to strengthen technical skills while nurturing soft skills, dispositions, and understandings that lead to being successful in diverse and multicultural working environments (Andrews, J. H. 2008). The goal is to design educational environments where students can apply knowledge learned in class through STEM experiences.

Recognizing that from 2006 to 2011, the total number of people employed in STEM occupations in the U.S. has increased by six percent (6%) and it is expected to grow by over 11 percent (11%) over the course of the current decade (Senator Bob Casey, Chairman , 2012). However, according to the Science and Engineering Indicators 2014, in 2011, among U.S. citizens and permanent residents, underrepresented minority students (African Americans, Hispanics, American Indians, and Alaska Natives) accounted for only 17% of students enrolled in graduate S&E programs. Therefore, there is a concern in the United States to resolve the issue of increasing the number of URM STEM graduates. According to the Commission on the Future of Graduate Education (The Path Forward, 2010), graduate education will be considered as the next bachelor degree (BS), or the lowest educational credential required for employment. In this report, the Commission pointed out those professional science master's degree programs, which stress interdisciplinary training, is part of this relatively new direction in graduate education. Projections indicate that within 30 years, Hispanics and African Americans will constitute over one-third of the American population (U.S. Census Bureau, 2010). Given these economic and demographic changes, more and more students, especially those belonging to underrepresented groups, will need to complete undergraduate degrees in STEM programs.

The importance of a transferrable innovative learning system model that is focused on an inclusive, integrative, experiential, and dynamic STEM undergraduate degree training is greatly warranted. Studies have demonstrated that *learning* is a lifetime process that supports a student's acquisition of knowledge, skills, attitudes and behaviors towards success not just while employed (Gardner, 1994; Fink 2003). One way to address this learning process is through *experiential learning*, which provides concrete experiences (i.e., laboratories, field works, problem sets), reflecting observations (i.e., journals, logs, discussion) abstract conceptualizations (from lectures, reports, project), and active experimentation in actual work environments (Kolb, 2004). The current literature on *experiential learning* strongly supports its effects on setting foundations for educational environments that require students to apply knowledge learned in the classroom while also exposing them to professional experiences (Andrews, 2008; Bass, 2012). The andragogical value of experiential learning relies on its ability to strengthen understanding of technical skills while also emphasizing soft skills and dispositions leading to college learners to enhanced problem solving proficiency in diverse and multicultural working environments (Andrews, 2008; Berrett, 2013). Hence, the goal is to design and implement educational environments that are based on experiential learning approaches.

The goal of the proposed global university-industry partnership initiative is to increase the students' employability by facilitating the creation of meaningful connections to the real world of work, and to develop the students' ability to navigate and negotiate the social, political, and practical dimensions of a workplace. This initiative develops an innovative educational model that provides students with hands-on practice through hybrid experiential learning methods such as cultural immersion, design projects, undergraduate research, and cooperative education. This model satisfies ABET criteria which seeks to enhance program outcomes without modifications to existing curriculum. In this initiative, students identify, formulate, and solve engineering problems by functioning in an international multidisciplinary team while building students' self-efficacy through direct interactions with industry professionals (2014-2015 Criteria for Accrediting Engineering Programs).

International Background

This global university-industry partnership initiative is designed towards educating and inspiring students to work collaboratively in a global setting, and to create an awareness of current social and economic issues. For instance, each project is intended to utilize the newest technology available while considering human interaction in long term social implications by focusing on solving a mobility problems. Multi-institutional teams allow for specific responsibilities and project oriented objectives collaborative addressed. One of these institutions is a design school and at least one engineering school should participate as a leader of the project. The project has multiple phases and components focused on affordability analysis for manufacturing, materials selection, CAD models, manufacturing analysis, manufacturability, carbon footprint, flexibility for manufacturing, business plan, and a facility layout design for the production of the device and plant safety. Each multi-institutional team is responsible for determining tasks and assigning responsible entities to accomplish them in a timely manner. Therefore, students participating in these projects are exposed to various learning environment where technical knowledge is accompanied with management, communication, and writing skills. Thus, this Global

University-Industry Partnership Initiative is about learning taking place in the effective, behavioral, and cognitive dimensions where relevant learning objectives are identified.

Methodology

The methodology employed in this initiative exposes students to a hybrid combination of technical challenges to design, prototype, and manufacture a mobile device within the context of an international competition where global collaboration is a key component to advance manufacturing concepts - the quick transfer of science and technology into manufactured products and processes - into practice. The venue for the global cooperation utilizes the highly effective academic-industry collaboration establishes under the Partnership for the Advancement of Collaborative Engineering Education (PACE). PACE is a partnership between General Motors, Siemens PLM Software, Autodesk, Hewlett Packard and Oracle to support strategically selected academic institutions worldwide to close the gap between engineering education and practice.

Under the PACE program, partner academic institutions are invited to participate in multi-year real-world projects through a global team-based competition. Student participation spans the design, engineering, and manufacturing of a transportation-focused product in teams of six or seven universities around the world with each specializing in at least one component of the technical requirements of the project. For instance, the overarching goal of the latest project was to provide an alternative and convenient mode of limited distance transportation for individuals residing in urban settings with additional market opportunities identified as individuals that walk to school, work, or travel between buildings that are physically spread across a large geographic area.

The specific objectives of this project focused on how to take a product from an initial design concept to full-scale manufacturing including design of the proposed manufacturing facility and consideration of relevant engineering factors. The project required student teams to meet specified weight, size and functional parameters. Other aspects of manufacturing considered in the project-included ergonomics, comfort of the product, build of materials required for manufacturing, and consideration of the potential market for the product.

Several students were recruited from various engineering disciplines to participate in this project at each university. The PACE team structure requires that a University be assigned as the lead institution, and subsequently serve the role of global project manager to ensure goals of the project are met within budgetary and time constraints and that the project meets the prescribed performance requirements. This lead institution is responsible for creating not only the infrastructure for communication and tasks management but also to create team synergism amid cultural differences and nuances while working across global time zones. Leadership changes in every project cycle. Thus, all universities have the same chances to experience the leadership roles. Student cultural competencies are embraced by this setup since they experience cultural variations and learn how to mediate discrepancies towards the success of the project.

In addition, every institution has a mentor, a faculty professor or program integrator assigned to work with students during the period of the project. The mentor role is crucial since he or she participates in meetings and supports students in the projects and in making decisions. However, caution is used to avoid excessive mentor participation that could lead to manipulation or bias the decision making process. Some cultures notably show preference on letting the mentor make several decisions, this action certainly affects the synergism of the whole global team and mainly affects the moral of the students in general. This practice has progressively changed through the years of participation on these projects thus current practices focus more on awareness of mentors to balance conflict that may arise among those institutions where cultural nuances support communication status levels or among institutions where there is no mentor involvement and students are totally entitled on making decisions.

Students from each university worked in small teams specialized in an area of the project to accomplish the assigned tasks and met with the global team on a weekly basis using latest communication technology. Students were selected to work on these projects based on completion of related engineering courses, design/sketching, working knowledge of English (oral and written), and/or courses in marketing. Each institution was responsible for providing faculty mentor(s), an identified place to work, and access to the necessary tools such as machine tools, equipment, and software packages to facilitate the development of the project.

The mentors and team facilitators are currently working on evaluating the impact of this experiential learning on the development of global skillset, perspectives, and self-efficacy. Data has been collected in regards to student major, college level, past experience, GPA, number of summer internships or Co-Ops offers, and students' self-efficacy beliefs. Self-efficacy is defined as "the judgment of one's capability to organize and execute the courses of action required to producing given attainments and that influences the choices, effort and persistence of human behavior but it varies in its level, strength and generality" (Bandura, 1977).

The primary goal of this initiative is to transform undergraduate education in engineering by developing a global experiential learning environment. Faculty mentors will assess the success of the program by monitoring changes in student attitude and academic performance. It is hypothesized that participation in a global learning environment will result in increased retention as well as improved alignment of knowledge and actions, and an ability to collaborate on multi-level projects on a global setting. It is expected that student performance and perception of competency in their subject will increase. The specific objectives of this initiative will be linked to data sources to yield appropriate information for process evaluation purposes.

Evaluation

Evaluation is a core component of the proposed global initiative which main goal is to improve the student experience in a global environment. This evaluation process consists of monitoring the development of the learning experience. Also, students need to evaluate the experience as a function of theory in combination with feelings by participating in a reflection session. Finally, feedback should be provided to the student to complement their reflection.

To accomplish this goal, the following specific objectives have been defined:

1. Increase the incorporation of global-centric, real-life, meaningful research and professional development activities in the classroom.
2. Increase the preparation of STEM students to enter an interdisciplinary multicultural work environment.
3. Increase students' professional judgment.
4. Incorporate collaborative research projects between academia and industry.
5. Incorporate collaborative research projects between academia and government.
6. Increase students' analytical reasoning and practical skills.
7. Train mentors (faculty, graduate students, and industry liaisons).
8. Recruit permanent partners from industry, government and across STEM fields
9. Increase students' employability

Results

The international collaboration has entered into its second major two-year project cycle with overarching goals being to design and build innovative and new transportation devices as outlined by a broad set of performance criteria established by the PACE leadership team.

Outcomes of these global team-based projects suggest participating students become effectively equipped members of a multidisciplinary team with the knowledge and skills required to take a project from initial design concept to full-scale manufacturing including design of the proposed manufacturing facility. The two-year project cycles comprised global teams consisting of six or seven universities from several countries and continents. Preliminary results show that students communicated and cooperated in a global environment amid different cultures, different languages and different time zones similar to a typical global company working on a real-world project. The multi-cultural team environment required a high sophisticated project management structure, clearly defined communication platforms, and strategies for shared data management.

Challenges were experienced throughout the first two-year project cycle that subsequently became the basis for best practices for future global collaborative projects. Specific challenges that students had to overcome included:

1. Unequal access to facilities for manufacturing of prototypes;
2. Actual student experience with direct hands-on application of math and engineering skills was vastly different;
3. Unequal capability for ordering comparable materials and supplies required to ensure effective product integration;
4. Changes within team composition as some students graduated and others joined the teams; and
5. Cultural nuances that led to ongoing clarification of agreed upon deliverables.

The entire group utilized industry accepted engineering design processes to ensure the developed prototype met the specified weight, size and functional parameters. Manufacturing aspects taken into account included ergonomics, comfort of the product for the consumer, the potential market for the product, consumer safety, and identification of the build of materials ensured both low-cost and functional attributes.

Lessons learned were vast. Through reflection, students communicated personal and professional growth in five key areas:

1. Diversity makes for strong teams,
2. Experience in hands-on application is critical to complementing math and engineering theory,
3. Plans are good but only effective if they plan with purpose,
4. Products can readily be designed but knowledge of the potential market makes them viable for manufacturing, and
5. Size and scope of projects demand clear and concise deliverables with realistic timelines.

Through participation in this global industry-university partnership it is expected that the new engineering graduate will be ready to enter into a professional life with a strong technical background, is observant and sensitive to the challenges posed by diversity and cultural differences, and is well versed in global product integration.

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