AC 2008-656: DEVELOPING ASSESSMENT TOOLS FOR INTERNATIONAL EXPERIENCES IN ENGINEERING EDUCATION

Ivan Esparragoza, Pennsylvania State University

Ivan E. Esparragoza is an Associate Professor of Engineering at Penn State Brandywine. His current research interests are in the areas of Global Engineering Education, Engineering Design Education, Innovative Design, and Global Design. He has introduced multinational design projects in a freshman introductory engineering design course in collaboration with institutions in Latin America and the Caribbean as part of his effort to contribute to the formation of world class engineers for the Americas. He is Vice-President for Region I and assistant of the Executive Director of the Latin American and Caribbean Consortium of Engineering Institution (LACCEI); in ASEE he is in the board of the International Division, and the Minority Division. His e-mail is iee1@psu.edu

Alexander Friess, Dubai Aerospace Enterprise University

Alexander Friess is an Assistant Professor of Engineering at Dubai Aerospace Enterprise University. He received his B.Sc. in Physics and M.Sc. and Ph.D. in Aeronautical Engineering from Rensselaer Polytechnic Institute. His research background includes experimental fluid dynamics, composite materials and performance optimization, and he has been active globally as consultant and design engineer working on a variety of projects, including participating in the design and engineering of South Africa's yacht for the America's Cup 2007. Current interests include instrumentation, renewable energy applications, and the field of engineering design (i.e. design innovation, inclusiveness and usability), as well as design education with a focus on multinational student collaboration and educating the "global engineer". His e-mail is Alex.Friess@dubaiaerospace.com

Maria M. Larrondo Petrie, Florida Atlantic University

Maria M. Larrondo Petrie, is a Professor of Computer Engineering and the Associate Dean of Academic and International Affairs in the College of Engineering and Computer Science at Florida Atlantic University, Boca Raton, Florida, USA. In ASEE she is on the boards of the Minorities in Engineering Division and the Women in Engineering Division, and the Web Master and past Secretary Treasurer of the International Division. She is Vice President of the International Federation of Engineering Education Societies (IFEES), and Co-Chair of the IFEES Global Engineering Education Summit that will be held in Cape Town, South Africa October 19-20, 2008. She was a past President and an Executive Council member of the Upsilon Pi Epsilon International Honor Society for the Computing and Information Disciplines, and a past Education Board member of the Association for Computing Machinery (ACM) Special Interest Group for Graphics (SIGGRAPH). Her current research interests are in the areas of Global Engineering Education, Complex Systems Modeling, and Secure Systems Development. She has written more than 150 refereed publications with over 100 citations, and has received funding for 21 grants and contracts totaling over $2,700,000. Her email is petrie@fau.edu.

Developing Assessment Tools for International Experiences in Engineering Education

Abstract

Many international initiatives have emerged in response to the increasing perception of the need to educate the new engineers with global competencies. Study abroad programs, multinational projects, blended courses with international experiences embedded, new courses in the curriculum about globalization and international research collaboration are some of the activities that are being used to help the students to develop abilities beyond the traditional analytical knowledge to be competitive in the global market. However, there is neither enough data nor formal assessment practices in place to formally evaluate the effectiveness of these initiatives in reaching the desired objectives. Additionally, their multinational and multicultural nature make more challenging the evaluation process due to the demanding time and resources. This paper reports a work in progress related to the development of assessment tools for international collaborative initiatives in engineering education. The final goal is to have a set of tools for objective assessment that can be adapted and/or adopted to measure performance, establish effectiveness and enhance quality of different international educational experiences.

Introduction

The rapid changes in technology as well as the flow of ideas, work, human resources, and merchandise around the world are causing more interdependence among the nations. Changes in the way in which people undertake economic production and organize the exchange of commodities represent an aspect of the great transformation of our age[1]. This brings more challenges to the industry since there is more competition but also brings more opportunities due to the transfer of capital and technology and the increment in trade of goods and services in the global market. This new social and economical model, known for many as globalization, requires the formation of professionals with global competencies. In the particular case of engineering, there is an increasing perception of the need to educate competent engineers for the global market; an engineer who must understand and accept diversity; be able to work in multi-national corporations; be able to work in multi-cultural teams; be creative in the solutions of problems impacting a wider and more diverse population; be able to communicate and socialize with people from different cultures; be knowledgeable in other language; be able to use the technology to exchange ideas, solve problems and present solutions; be a leader, an excellent team member, and an ambassador[2]. As a result, a group of organizations on this hemisphere such as Engineering for the Americas (EftA), the Ibero American Science and Technology Education Consortium (ISTEC), and the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) have started developing initiatives to bring together the academia, the industry and governments in the region to identify and facilitate international collaboration initiatives in engineering education and research to foster the development of global competencies through the engineering curriculum, and to promote mutual recognition of engineer students across the boundaries and cross-border trade agreements facilitating the flow of work and human resources throughout the hemisphere to optimal locations for distributed economic development[3].

The development of educational and research initiatives must be accompanied by an appropriate assessment process. The motivation for this work stems from the need to develop robust assessment strategies and associated assessment tools specifically designed for international collaborations in engineering courses. While the concept of international collaboration is being implemented on a regular basis[2,3], no robust and specific assessment framework has been developed. This work aims at addressing this need.

The development of the assessment process and tools for international collaborative engineering education projects requires the identification of Global Competencies[4] that the international nature of the initiative specifically targets.

According to the National Science Foundation (NSF) in its handbook for project evaluation[5], there are two fundamental reasons for evaluation of projects: 1) obtain information on whether goals are being met and on how different aspects of a project are working and are essential to a continuous improvement process, and 2) evaluations frequently provide new insights or new information that was not anticipated called "unanticipated consequences" of a program which are among the most useful outcomes of the assessment enterprise[5]. Therefore, the effectiveness of the international collaborative initiatives can be determined by a well established assessment mechanism.

This paper reports a work in progress related to the development of assessment tools for international collaborative initiatives in engineering education, particularly for those sponsored by LACCEI. The final goal is to have a set of tools for objective assessment that can be adapted and/or adopted to measure performance, establish effectiveness and enhance quality of different international educational experiences.

Global Education Initiatives

The increasing perception of the importance of internationalizing the engineering curriculum has caused that many institutions around the world have started implementing different programs to target that goal. The most common initiatives were identified in a previous manuscript[6] and they are categorized and summarized as follows:

1. Education
   a. Accreditation and quality assurance workshops
   b. Study abroad programs:
      i. Undergraduate education abroad (semester or year long experience studying in a foreign country)
      ii. Graduate education abroad (semester or year long experience studying and doing research in a foreign country)
      iii. Embedded education abroad (undergraduate or graduate course with a brief international experience embedded. Usually one or two weeks of the course work is done abroad)
      iv. Dual degree programs (students can complete part of the work in a foreign institutions and obtain a degree from the home and the foreign institution)

    c. Faculty development programs (Doctoral degrees in US institutions for engineering faculty in Latin America and the Caribbean)

    d. Share courses (development of courses that can be shared by different institutions across the Americas)

        i. Engineering Design and Innovation

        ii. Entrepreneurship (adapted to each location)

        iii. Leadership (with emphasis in global skills)

2. Research

    a. Collaborative research projects in the Americas

        i. Thesis and dissertations

        ii. Industry and government driven research projects

3. Multinational Projects

    a. Capstone and design projects (course and student competition related)

    b. Service learning projects

        i. Engineering Projects in Community Service (EPICS)[7]

        ii. Engineering Without Borders (EWB)[8]

        iii. Engineering for a Sustainable World (ESW)[9]

Any initiative independent of its size and nature should be evaluated to obtain information, assess its impact and identify opportunities for improvement. In analyzing the global education initiatives described in the above, it is found an ample variety of programs and tasks that have been adopted and adapted to educate world-class engineers. The size and description varies from small modulus that can be incorporated in a class, to a bigger and more complex collaborative research project. Therefore, the assessment model and strategy should be tailored to the program under consideration.

What is a Global Component?

The target of the above collaborative efforts (and at the same time the difference to the traditional engineering coursework) in engineering education is, in addition to cultivating the core competencies required for the specific subject of the interaction (Knowledge, Skills, Abilities and Behaviors), to introduce and foster explicit Global Competencies (as an additional item in the competencies list) in the engineering student. The topic of specifying global competencies is a widely argued one[10], and no universal definition has been reached. Terms such as Global Citizen, Global Proficiency, Global Process Competence, etc aim at defining the elusive competencies that qualify the skills required for today's global marketplace.
For the purpose of this manuscript, the Global Competencies for Engineers as defined by Downey et.al.[4] will be adopted. They are based on the notion of different point of view, a different problem definition for engineers trained in different environments. These Global competencies introduce an added dimension to the traditional key competency categories by specifically addressing learning criteria and outcomes relevant to the global experience[4]:

Learning criterion:
- *Through course instruction and interactions, students will acquire the knowledge, ability, and predisposition to work effectively with people who define problems differently than they do.*

Learning Outcomes:

- *Students will demonstrate substantial knowledge of the similarities and differences among engineers and non-engineers from different countries.*
- *Students will demonstrate an ability to analyze how people's lives and experiences in other countries may shape or affect what they consider to be at stake in engineering work.*
- *Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in the process of problem definition and problem solution.*

In order to assess an international collaborative experience in engineering education, these criteria need to be specifically introduced into the overall assessment scheme.

Assessment Methodology and Tools

The global initiatives presented in the previous section were categorized in main headings; however, independent of the type of initiative to be assessed the two different kinds of evaluations suggested by the NSF in its handbook for project evaluation[5], formative and summative, will be adopted in each case as part of the evaluation of the progress of activities and the final outcome assessment. The overall assessment process proposed is depicted in Fig. 1.
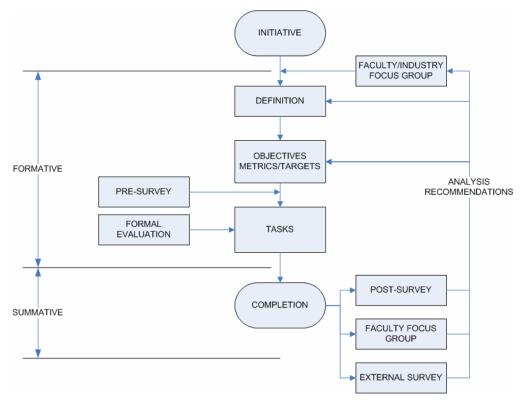

Figure 1 Assessment process for global initiatives

The model follows the subsequent steps:

1. Identify the need or opportunity
2. Create a Faculty/Industry focus group
3. Define the initiative.
4. Create the Overall Assessment Design Matrix: Define the goal, tasks, competencies, and outcome metrics.
5. Design of assessment tools.
   a. Pre-survey
   b. Formal evaluations
   c. Post-survey
6. Analysis of data and recommendations (feedback)

The assessment mechanism will have quantitative and qualitative data for measurement purpose, and these data will be collected by using the appropriate assessment tools[11]. The measurement tools that will be used are:

1. OVERALL ASSESSMENT DESIGN MATRIX[11]: This matrix is basically the strategic plan for the initiative reflecting the goal, objectives, and targets. Al future surveys and forms of evaluation will be based on the information presented in this matrix. This will serve as the guideline for the structure of the activities, tasks, students' performance and content evaluations.

2. SURVEYS. Two internal surveys will be designed for each initiative: a pre-survey given before the beginning of the tasks to learn about the actual knowledge and skills level of the participants regarding the specific competencies that the particular activity is designed for, and a post-survey given after the completion of the activity to determine the level of enhancement on each competency. Each survey will have quantitative and qualitative questions using different formats such as Likert scale questions, multiple choice, option list, checkbox and open questions. A post employment or job survey will be also designed and implemented to obtain feedback from the real employers. The challenge for this survey is the global nature of the assessment. Even for small and local companies the survey should reflect somehow the global competencies.

3. COURSE-BASED EVALUATION. Student will be evaluated with regular exams, project reports, and presentations during the execution phase of the initiative.

4. FACULTY SURVEY. Faculty involved in the initiative will also evaluate the initiative through a survey where they will share their impressions. The survey for the faculty will have a similar format that those given to the students.

Assessing Global Initiatives

There are two distinctive activities that need to be assessed when international activities are established: Content evaluation and student's performance evaluation.

Content Evaluation:

This is related to the evaluation of the structure and content of the activity. In this case the instructors along with the industry evaluate the opportunity, and define the activity through an initial focus group discussion based on the analysis of the needs using literature search, interviews and surveys. This step set the tone for the definition of learning objectives and specific tasks to be included in the program. The result of this is the *Overall Assessment Design Matrix* whose general template is shown in Table 1.

Table 1 Assessment Design Matrix Template

INITIATIVE DESCRIPTION					
ACTIVITIES	TASKS	COMPETENCIES	LEARNING OBJECTIVES	KEY	OUTCOMES MEASURES
A	B	C	D	E	F

A. *Activities:* This field contains the main general activities to be carried out in each particular initiative. The activities could be limited to one for small international components or could have several activities for bigger collaborative projects.

B. *Tasks:* This field contains more specific tasks to be completed for each particular activity

C. *Competencies*: This field has the outcome statement of knowledge, skills, attitude, and global competencies the students have to reach to demonstrate their learning. Each task has one or more associate competencies. Competencies describe the performance of a major skill. They begin with an action verb that matches the means of performance assessment; tell learners what they will be able to do as a result of a given learning experience; describe the intended outcome, not the learning process; specify a single performance/not a combination; describe the learner's performance, not the instructor's; and they are measurable and observable[13].

D. *Learning Objectives:* This is an even more specific outcome statement as compared to the competencies statement. Learning objectives will be in the same format and meet the same criteria as competencies, but should be at the same or, more likely, a lower level. Learning objectives reflect what learners must do in an educational setting to achieve a specific related competency. They tell learners what supporting skills, knowledge, and attitudes they will learn; begin with an action verb; and they are measurable and observable[13].

E. *Key:* In this field, the competencies are identified by a key. K is used for Knowledge, S is used of skills, G is used for Global and A is used for attitude and behavior.

F. *Outcomes measures:* This field has the outcomes measures.

The whole initiative has to be subjected to a final evaluation including all the stakeholders. At the end of the project the instructors involved go through an internal assessment process where they identify the strength and weaknesses of the experience. The students will be asked to provide feedback about the content, pace, resources (human, technological and learning material), and the instructors. External stakeholders such as the industry and government agencies might be invited to provide information regarding the learning objectives, project's content and deliverables also.

Students Performance Outcomes

The other assessment activity is related to the analysis of students' performance. In this case the assessment tools are designed to establish how well the students are achieving the stated goals for the initiative. This is continuous process that starts with a preliminary survey to determine the level knowledge and specific skills that the initiative is trying to enhance. It continues with the formal evaluation created for the specific activity such as exams, reports, presentations, etc. The whole process will finalized with the post-survey where students will reflect what they have learned, developed, and/or improved.

The assessment tools are basically a set of questions targeting specific concepts. One of the most challenging tasks is the design of the questionnaire for the surveys in the assessment process, especially when the development of competencies beyond the analytical knowledge is evaluated. Contrary to analytical knowledge that can be easily evaluated through close problems with unique solutions, skills, behaviors and attitude are more difficult to quantify and evaluate. Therefore, an effective methodology must be developed to translate qualitative data into quantitative data for statistical analysis and synthesis. The questionnaires must be carefully designed to clearly assess the qualitative and quantitative aspects of global initiatives. It is not the intention to start developing questions that have to be subjected to an evaluation process per se. Instead of that, the idea is to use proven effective questions in the evaluation of competencies and skills and adopt and adapt them to the global initiatives. One source to be used is the Linda Suskie's book "Questionnaire Survey Research What Works"[12]; other sources can be found in Internet sites specialized in this field.

Before the questionnaires are generated, the objectives for the initiative must be set up using the SMART approach. This means that each objective must be specific, measurable, achievable, realistic, and time-bound. Well defined objectives will make easy to generate the questionnaires.

Future Plans and Conclusion

This is a work in progress and the authors are interested in getting feedback and existing data for the development of general guidelines and templates as a source of information to promote the assessment of international initiatives in engineering education and research. The immediate plan is to start developing a data based of questions and evaluation tools that can be adopted and adapted for pre and post-surveys as well as for formal evaluation mechanism. A complete set of tools is expected to be tested with specific projects which are currently managed by the authors, and the initial outcomes are estimated to be reported in the 2009 ASEE conference.

The international engineering education and research community is growing, and more and more activities, initiatives and projects are anticipated in the near future; therefore, it is important not only to promote changes in paradigm of education but also to have the proper assessment tools to evaluate the effectiveness of international programs in education and research.

Bibliography

1. Steger, Manfred. Globalization: A very short introduction. Oxford University Press. 2003. pp. 147
2. Esparragoza, I.E., and Devon, R. Forming Global Engineers: A Freshman Engineering Design Course with a Multinational Design Project Involving Latin American Institutions. *Proceeding of the 2007 ASEE Annual Conference and Exhibition, Honolulu, Hawaii June 24 to 27, 2007, AC 2007-1188. Invited paper to the 6th ASEE Global Engineering Colloquium, Istanbul, Turkey Oct. 1-4, 2007*
3. Jones, R.C., 2005, International S&T Initiatives for African Development, WFEO Committee on Capacity Building Report to the National Academies, 2005. http://www7.nationalacademies.org/guirr/1Jones.ppt#256, 1,INTERNATIONAL S&T INITIATIVES FOR AFRICAN DEVELOPMENT
4. Downey, G.L., Lucena, J.C., Moskal, B.M., Parkhurst, R. et. Al. The Globally Competent Engineer: Working effectively with People Who Define Problems Differently. *Journal of Engineering Education*; April 2006; 95,2.
5. NSF 02-057, The 2002 User-Friendly Handbook for Project Evaluation. http://www.nsf.gov/pubs/2002/nsf02057/start.htm
6. Esparragoza, I.E., Larrondo-Petrie, M., Jordan, R., and Paez, J. Forming the Global Engineer for the Americas: Global Educational Experiences and Opportunities Involving Latin America and the Caribbean. *Proceeding of the 2007 ASEE Annual Conference and Exhibition, Honolulu, Hawaii June 24 to 27, 2007, AC 2007-576.*
7. http://epicsnational.ecn.purdue.edu/.
8. http://www.ewb-usa.org/
9. http://www.esustainableworld.org/
10. Hunter, W.D., Got Global Competency?. *International Educator*, Spring 2004; 13,2.
11. Morell, L., Zayas, J.L., Lamancusa, J., and Jorgensen, J. Making a partnership work: outcomes assessment of a multi-task, multi-institutional project. *Proceeding of the 1997 ASEE Annual Conference and Exhibition, Milwaukee, WI., June 15 to 18, 1997, Session 2266.*
12. Suskie, Linda. Questionnaire Survey Research, What Works. 2nd Ed. Association for Institutional Research. http://www.airweb.org/page.asp?page=88
13. http://its.foxvalleytech.com/iss/curric-assessment/Learngob.html