

Assessing Collaborative Global Design Projects among Engineering Students from US and Latin America

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ABSTRACT

A collaborative network of institutions from US and Latin America has developed and executed collaborative global design projects as part of academic experiences for their students. The main goal of these projects is to foster international collaboration and to offer an opportunity to the students to develop professional skills through international teamwork effort in the solution of a design problem. There is anecdotal evidence that students have found the experience rewarding and successful; however, there is no a formal assessment approach to determine the effectiveness of this initiative in reaching the desired goal and objectives. This paper reports an assessment framework and proposed assessment tools for the collaborative global design projects carried out by the international collaborative network with the aim to evaluate the effectiveness of this approach and to explore option to enhance the content and delivery method of the projects.

Keywords: Collaborative projects, global design, assessment tools

1. INTRODUCTION

Contemporary engineers are expected to collaborate in teams consisting of individuals from diverse countries with different languages and cultures, and be prepared to use the technology for communication, solving problems and presenting their solutions. (Pinzón and Esparragoza, 2008). Engineering accreditation agencies such as ABET have taken into account these demands and have included them in their professional outcomes (ABET, 2009) As a result, engineering programs should facilitate, as early as possible, academic experiences to their students to promote the development of professional skills and international experiences as part of their formal education. One way to do this is through multinational global design projects in which engineering students work in geographically disperse teams to solve an engineering problem.

Esparragoza et al. (2007) have reported on the design and implementation of collaborative work among teams of students from one university in the US and several universities in Latin-America to solve design projects, using available technology for communication. The stated aims of the multi-national project were to provide students with the opportunity to work in a globally distributed team, learn the value of different ideas from different cultures, gain knowledge of design opportunities in other countries and become skilled at how to use collaborative

tools effectively. The global design project was used to foster cultural awareness and to stress the importance of diverse teams in the solution of real engineering problems. The collaborative global design project has been repeated every semester with different Latin American universities depending upon the academic calendars of the participating institutions.

Anecdotal evidence shows that students found the experience rewarding and useful (Esparragoza, et al. 2007); however, there is a need to assess to what degree the stated aims of the collaborative exercise is being met. Most students are freshmen or sophomores and within their curricula this is their first design and team experience, so adding the international collaborative dimension is a challenge. Additionally, there seems to be some evidence that students do not see themselves as part of a single distributed team working to solve a problem, but rather as parts of local teams collaborating for portions of the design project with their assigned partner teams (Duque, 2010) and, with the potential danger that some teams could be viewing the exercise as competitive rather than collaborative. This challenge could be attributed to the framing of the exercise, or to the fact that as the collaborative work is conducted at such a fast pace, there might not be enough time to build trust, a recognized challenge for team work and performance in distributed teams (Pinzón and Esparragoza, 2008)

In the present paper with the stated aims and set up of the international collaborative work as background, the current assessment tools used for evaluating student work are reviewed, and a proposal for an enhanced assessment framework and tools to assess collaborative design projects among engineering students in the US and Latin America, is presented.

2. BACKGROUND

As mentioned earlier, the global design project is used to foster cultural awareness and to stress the importance of diverse teams in the solution of real engineering problems. The stated aims of the project are to provide students with the opportunity to work in a globally distributed team, learn the value of different ideas from different cultures, gain knowledge of design opportunities in other countries and become skilled at how to use collaborative tools effectively.

In operational terms, faculty of the participating institutions agrees on the design project to be tackled with a view to search for solutions to a relevant problem in developing countries. Recent projects have included design of prosthetic legs for children victims of land mines, and the design of shelters for refugees of man or nature caused disasters. In the initial definition of the design problem, students receive a contextual description stressing the importance of the general problem to be solved.

The project design experience is 8 week long and includes 4 virtual meetings using a collaborative platform. The overall objective of the project as stated in the project handout called Americas by Design is to demonstrate the feasibility of providing the engineering students of the participating institutions with collaborative, cross-national, design team experiences. The document includes a list of expected learning outcomes, a schedule and expectations for deliverables, and a suggested list of issues for the students to evaluate their experience.

Examples of the project collaborative network, a project schedule, and design methodology for a typical project exercise are shown in Figures 1, 2 and 3 respectively. Students are first or second year engineering students from Penn State University at Brandywine and from different universities in Latin America including the Universidad APEC in Republica Dominicana, the Escuela Superior Politécnica del Litoral in Ecuador, Universidad EAFIT and Universidad Autonoma de Occidente in Colombia, and Pontificia Universidad Catolica Madre y Maestra in Dominican Republic and Universidad del Táchira in Venezuela; other Colombian, Dominican and Peruvian universities have participated in the exercise in the past, depending upon the institutions course calendars.

Students are required to use the Breeze meeting facility to which Penn State University gives free access to the Latinamerican Teams, Collaber a collaborative work platform, electronic mail and the course management systems for the corresponding universities. Additionally the project document suggests the use of other tools such as Google tools, and social networks. In terms of hardware and connectivity each university must provide access to e-mail accounts to their students, access to computers with internet connections, web-cams and audio

equipment. Also for the design process universities should give students access to design software such as Solidworks, Autocad or similar.

As shown in the schedule and design methodology, teams are asked to specifically share pieces of information during the scheduled virtual meetings. The first virtual meeting is meant for establishing personal relationships. The stages of the design process for which sharing are required are: the definition of design objectives, functions and constraints; the functional structure and specifications; and finally the design concepts. The remaining tasks are to be developed locally, although sharing is neither encouraged nor forbidden.

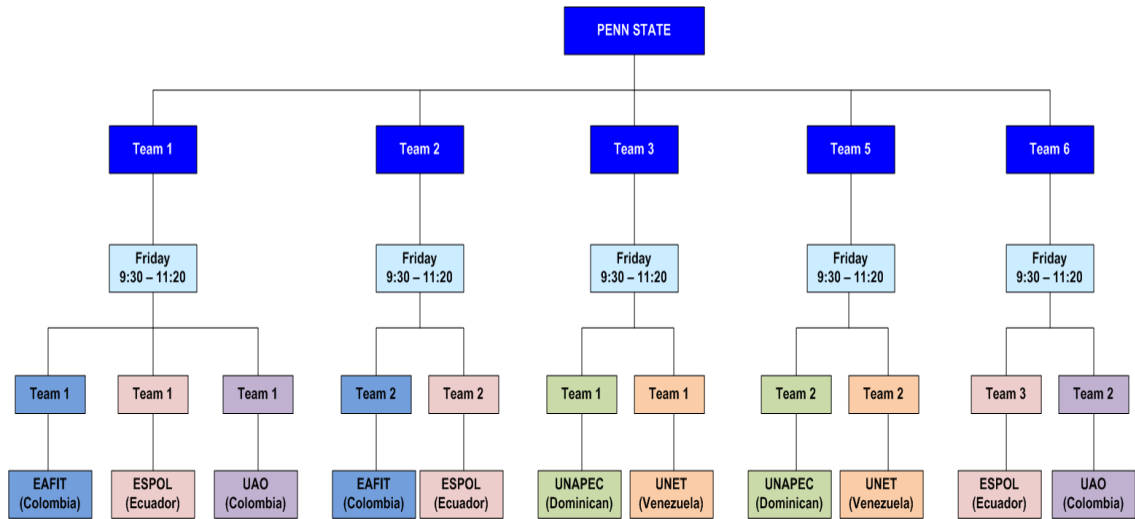


Figure 1. Example Project collaborative network

No.	Activity	Date
1	Assign the project	Oct. 5, 2009
2	Understanding the project locally	Oct. 5 to 12
3	Test the equipment for AV conferences	Oct. 5 to 12
4	AV-1 Conference: Establishing personal relations	Oct. 16, 2009
5	Understanding customer needs	Oct. 12 to 16
6	AV-2 Conference: Discuss customer needs (objectives, functions, constraints)	Oct. 23, 2009
7	Functions and specifications	Oct. 19 to 23
6	AV-3 Conference: Discuss function decomposition and design specifications	Oct. 30, 2009
9	Concept generation	Oct. 26 to 30
10	AV-4 Conference: Discuss concept ideas	Nov. 6, 2009
11	Concept selection	Nov. 2 to 6
13	Develop 3D Model	Nov 6 to Dec. 9
14	Prepare final report and presentation	Nov. 6 to Dec. 9
15	Submit final report and presentation	Dec. 11, 2009

Figure 2. Example project schedule

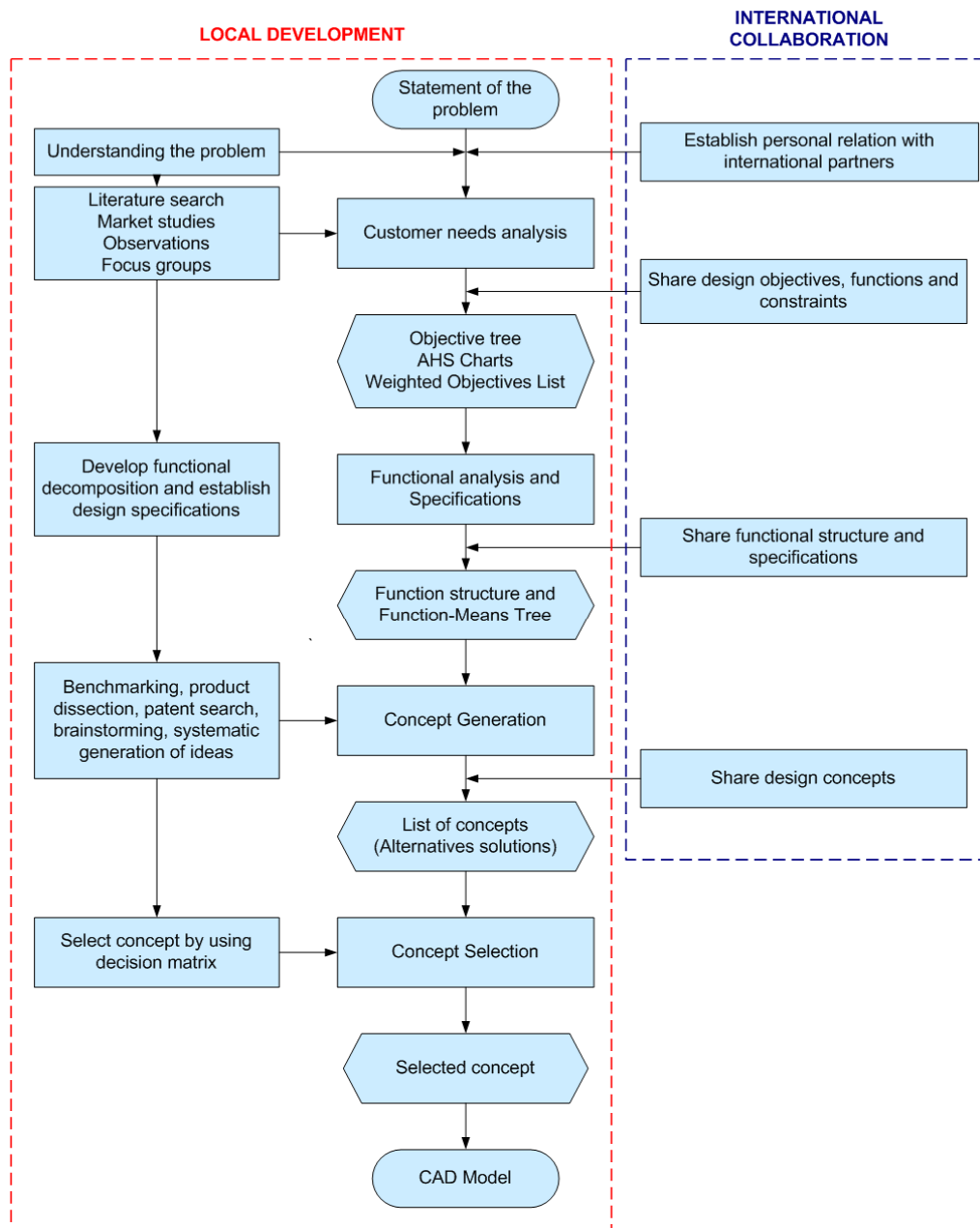


Figure 3. Design methodology for the project

3. ASSESSMENT

The collaborative global design projects are used as a mechanism to transfer knowledge to the students and to allow the students to develop professional skills and competencies. In this section first the learning outcomes of the project are presented and then the assessment approach is described. The proposed assessment tools are described in section 4.

a. Learning Outcomes.

The stated learning outcomes for the collaborative project have been defined as:

1. Experience a globally distributed design team

2. Learn the value of different ideas from different cultures
3. Enhance creativity
4. Develop ethical values
5. Foster leadership
6. Learn about the design opportunities in other countries
7. Make friends in other countries
8. Learn to use collaborative tools

b. Assessment Approach

A general process to be followed to develop an assessment process of educational experiences includes a definition of the learning outcomes of the experience, a determination of the components of the outcomes, a determination of the performance criteria that define the outcome, and the design/adoption/adaptation of assessment tools, either direct or indirect to assess performance of the students.

Outcomes 1 to 4 of the collaborative project deal with the international design exercise itself and consider, albeit not explicitly, what for collaboration in virtual environments, Barron (2003) as quoted in Lainonen et al (2005), defines as the content space (the problem to be solved) and the relational space (the social interactions challenges and opportunities). That author states that the way in which team members manages in both spaces is critical to the outcome of their work. The assessment process is then developed considering the performance of the team members in the content and the relational spaces. Outcome 5 is oriented towards the use of tools and could enhance or hinder the value of the collaborative experience, as such is considered part of the relation space.

b.1 Relationship space:

The design methodology calls for one virtual meeting for establishing personal relations with international partners (see Fig. 3 above). Also, even though not made compulsory, the use of virtual social networks such as Facebook is encouraged. The globally distributed team portion of outcome 1, outcomes 2, 4 and 5 pertain to this space.

The design methodology also specifies three virtual meetings for sharing information (Fig. 3) and the perception of team members regarding the openness and quality of the interactions constitute important elements for the perceived success of the team experience. So the perception of students regarding the quality of the sharing process is key to his satisfaction with the experience.

Table 1 shows for the relationship space the relevant elements of the outcomes and the performance criteria involved. The team portion of the outcome elements and performance criteria are lightly adapted from Chiluita (2009) for global teams.

b.2 Design Space

The collaborative experience calls for three virtual meetings for sharing relevant design information (see Fig 3). The satisfaction of the team members with the collaborative experience will depend on the perceived adequacy of the quantity and quality of the shared information. Faculty also needs to assess the impact of the interactions and need to have tools to do it.

Table 2 shows the matrix of learning outcomes elements with their corresponding performance criteria. The elements are based on the design process as shown in Figure 3.

Table 1. Matrix Learning outcomes elements with performance criteria, Relationship space.

Outcome/Elements of the outcome:	Performance Criteria
1.1 Virtual meeting for establishing personal relation with international partners	1.1.1 Rapport with partners 1.1.2 Exchange of relevant contact information 1.1.3 Sharing of social networking addresses 1.1.4 Agreement of language and format for work and communications
1.2 Sharing of design information	1.2.1 Perceived openness for sharing design objectives, functions and constraints 1.2.2 Perceived openness for sharing functional structure and specifications 1.2.3 Perceived openness for sharing design concepts 1.2.4 Perceived openness for discussing and sharing other relevant design information
2.1 Learn the value of different ideas from different cultures	2.1 Listen to what international partners have to say or propose. 2.1 Show respect for opinions different from your own. 2.1 Encourage international partners to participate 2.1 Be courteous in the interaction with your team partners.
4. Make friends in other countries	4.1 Number of interactions with project partners for issues not related to the project. 4.2 Number of interactions with former project partners after the end of the project period for issues related and unrelated to the project.
5. Learn to use collaborative tools	5.1 Use of the Breeze platform 5.2 Use of the Collaber tool 5.3 Use of Google collaborative tools 5.4 Use of social networking tools

Table 2. Matrix Learning Outcomes elements with performance criteria, Design space.

Outcome/Elements of the outcome:	Performance Criteria
1.1 Sharing of design information	1.1.1 Perceived adequacy of quantity and quality of design objectives, functions and constraints 1.1.2 Perceived adequacy of quantity and quality of shared functional structure and specifications 1.1.3 Perceived adequacy of quantity and quality of shared design concepts
1.2 Sharing of other relevant design information	1.2.1 Perceived adequacy of the quantity and quality of other shared relevant design information
3. Learn about design opportunities in other countries	3.1 Number and quality of interactions with project partners on issues related to their local peculiarities with regards to the design project.

4. PROPOSED ASSESSMENT TOOLS

When possible, direct assessment is the preferred choice to evaluate performance of students in any of the learning outcomes. Project evaluations and faculty evaluations of performance are examples of direct evaluation. Perceptions, however, are normally evaluated using indirect measures such as interviews and/or surveys.

Engineering faculty when evaluating the quality of design projects normally resort to the evaluation of team written reports and/or oral presentations and they try to assess the degree of participation of team members in the work through team member performance in the oral presentations. In order to have more control on the progress

made in the design process, partial reports are normally asked from the teams so that faculty could identify whether difficulties are arising and intervene.

These assessment process and tools are considered adequate, and this paper proposes that these be expanded to adequately evaluate the performance of students in the type of project of interest and to assess student satisfaction with the experience as a proxy for the quality of the collaboration.

The assessment tools are under development and only a sample of the developed/adapted assessment tools are presented in this paper, in particular for assessment of two outcome components in the relationship space and one outcome of the design space are presented.

To assess outcome 1.2 Sharing of design information, in the relationship space, a survey has been designed and it is shown in Table 3. The statement has to be measured on a 5 point Likert scale from strongly agree to strongly disagree.

To assess outcome 1.3 Learn the value of different ideas from different cultures a rubric that each student member of a team have to apply to evaluate its peers is suggested, as per Chiluiza (2009). A portion of this rubric is shown in Table 4.

To assess 1.1 Sharing of relevant design information in the design space, faculty evaluations of reports of teams prior and after a virtual meeting and comparison of results with the reports of partner students to their corresponding faculty members at the different schools is proposed. The proposed tool is shown in Table 5.

Table 3 Survey questions for assessing Outcome 1.2 Relationship space.

Performance criteria	Survey questions
1.2.1 Perceived openness for sharing design concepts, functions and constraints	Partners from University X were very open for sharing design objectives, functions and constraints.
1.2.2 Perceived openness for sharing functional structure and specifications	Partners from University X were very open in sharing functional structure and specifications.
1.2.3 Perceived openness for sharing design concepts	Partners from University X were very open in sharing design concepts
1.2.4 Perceived openness for discussing and sharing other relevant design information	Partners from University X were very open for discussing and sharing other relevant design information

Table 4. Sample rubric elements to assess Outcome 2.1 Relationship space (Source: Chiluiza, 2009 with modifications by the authors for use in international team settings)

Performance criteria	Rubric
2.1 Listen to what international partners have to say or propose.	<i>Beginner:</i> Listens ideas and opinions of international partners in maximum 25% of the cases <i>Developing:</i> Listens ideas and opinions of international partners in maximum 50% of the cases <i>Developed:</i> Listens ideas and opinions of international partners in maximum 75% of the cases <i>Excellent:</i> Listens ideas and opinions of international partners in more than 75% of the cases
2.2 Show respect for opinions different from your own.	<i>Beginner:</i> Respects ideas different from his own from international partners in maximum 25% of the cases <i>Developing:</i> Respects ideas different from his own from international partners in maximum 50% of the cases <i>Developed:</i> Respects ideas different from his own from international partners in maximum 75% of the cases <i>Excellent:</i> Respects ideas different from his own from international partners more than 75% of the cases.

Table 5. Items for faculty to assess Outcome 1.2 Sharing of design information

Performance criteria	Items to evaluate
1.1.1 Perceived adequacy of quantity and quality of design concepts, functions and constraints	Quantity of design concepts, functions and constraints prior and after interaction. Quality of design concepts, functions and constraints.
1.1.2 Perceived adequacy of quantity and quality of shared functional structure and specifications	Quantity and quality of functional structure and specifications prior and after interaction
1.1.3 Perceived adequacy of quantity and quality of shared design concepts	Quantity and quality of design concepts prior and after design concepts.

5. CONCLUSIONS

There is a clear necessity of developing assessment procedures and tools to properly evaluate the development of professional skills in the engineering students' population and the effectiveness of class projects and teaching approaches in reaching the desired goals. This work is the first effort of the authors to tackle this issue and it is expected to develop a framework and be an ongoing process to enhance the collaborative project initiatives and other similar activities. The immediate plan is to develop a set of questionnaires and rubrics to be used in pre and post surveys as well as for formal evaluation mechanism for the projects.

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