Pre- and Post- Evaluation of Students Interest on Multinational Projects based on Class Standing and Gender

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Abstract – Multinational engineering design projects have been implemented at various academic institutions in order to offer their students exposure to the issues present when work needs to be carried out globally. Such implementations try to emulate the working environment that exists in many engineering projects being done in practice. These experiences are something that academic institutions need to include and emphasize in their programs, and are gaining acceptance at a variety of colleges and universities worldwide. The importance of such activities is something that students need to be aware because of its benefit, and students should be motivated to participate. The main goal of this study is to determine the level of interest by engineering students participating in a multinational collaborative design project, making a comparison of that indicator at the start and at the end of their participation. Such comparison is done for the entire group of students, and is reported as well based on class standing and gender. For this purpose, a survey based on the Intrinsic Motivation Inventory (IMI) was administered to the students, and data collected provide information on the level of interest or enjoyment that they report. This interest construct provides an indication of the students' interests, beliefs, and feelings about the international project that reflect their level of motivation to undertake such task. The results of the comparison indicate the need to define intervention that result in more uniform level of interest by students.

Keywords: Student Interest, Multinational Project, Gender, Class Standing, International Collaboration.

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Abstract – Multinational engineering design projects have been implemented at various academic institutions in order to offer their students exposure to the issues present when work needs to be carried out globally. Such implementations try to emulate the working environment that exists in many engineering projects being done in practice. These experiences are something that academic institutions need to include and emphasize in their programs, and are gaining acceptance at a variety of colleges and universities worldwide. The importance of such activities is something that students need to be aware because of its benefit, and students should be motivated to participate. The main goal of this study is to determine the level of interest by engineering students participating in a multinational collaborative design project, making a comparison of that indicator at the start and at the end of their participation. Such comparison is done for the entire group of students, and is reported as well based on class standing and gender. For this purpose, a survey based on the Intrinsic Motivation Inventory (IMI) was administered to the students, and data collected provide information on the level of interest or enjoyment that they report. This interest construct provides an indication of the students' interests, beliefs, and feelings about the international project that reflect their level of motivation to undertake such task. The results of the comparison indicate the need to define intervention that result in more uniform level of interest by students.

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I. Introduction

Almost in every design engineering activity taking place all across the globe there will be a collaborating team working on the task. Such teams might be at local, regional, national or international, which implies that today's engineers need to have the skills to work in a collaborative environment when doing engineering design work. Those professional skills are something that many academic institutions around the world are trying to offer their students in order to have job ready graduates. Teamwork, communication, and global awareness are part of that set of professional skills that have become essential in an engineering curriculum. Participating in collaborative design efforts is increasingly becoming a central activity in the design of every product. In fact, because of the growing complexity of today's products, their development requires to integrate knowledge and skills across disciplines and organizations with great level of engagement and participation by diverse parties. Working in a collaborative environment provides the advantages of having complementary resources, information and ideas that compensate for the limitations of a design done individually. The final result is a product that cannot have been achieved by any individual working alone.

Working in multi- or inter-disciplinary projects is inherently challenging, and effective collaboration may require new ways to share information. These challenges "… include aspects such as differences in language, culture, education, and government regulations, as well as teams working across different time zones around the world" [1]. As result of these challenges, there is a growing demand for professionals who are able to effectively and efficiently communicate and collaborate with partners from different countries and cultures [2]. The surge of information technology, in particular developments like cloud computing, improves the capacity of sharing information between teams of designers located around the world, and provides the infrastructure necessary for an integrated and distributed engineering environment [3].

There are educational challenges regarding the training experiences offered to students so that they acquire the skills necessary to operate in an interdisciplinary and intercultural collaborative environment. As a result, many engineering programs are incorporating multinational collaborative projects through their curriculum in order to emphasize the development of global competencies in their students in addition to the technical knowledge of a particular discipline. These projects are characterized by having teams geographically dispersed but working on a common design project. One such project involves students from the US, Latin America and Europe [4], and is used as a subject of this study. While international projects offer new opportunities for diversification and expansion, they also introduce new risks because of the differences in the marketplace, culture, administrative, geographic, and economic aspects between the organization's home market and the project's host country [5].

The motivation of students is a key issue to succeed in any academic task. This is especially true in practical experiences such as international collaborative projects where students must be motivated to spend time to share ideas and information with foreign colleagues even when there is no explicit or immediate assessment performed. That is, students

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have to be intrinsically motivated, meaning that their source of motivation is in the performance of the task itself [6]. The design task should be such that students feel motivated to behave in proactive, open minded and collaborative fashion, the expected level of effort is high, and the expected level of persistence to arrive at an acceptable final design is high as well. Motivation of students needs to be across the curriculum, since there is a need at upper class levels [7], but it is important to consider how to best support early year engineering students' motivation and self-regulating learning [8]. In these years is when students are more likely to drop out [9]. Additionally, it is claimed that the diversity in the teams to be an important aspect in the development of the design task. In some engineering programs the participation of female students is low [10]. Segregation observed in teamwork, including interaction based on gender, could result in possible reduction in the motivation of a team. The gender is a useful category of historical analysis, and it is typically utilized to represent the role of women in different fields [11].

The aim of this paper is to determine the level of interest of engineering students participating in a collaborative multinational design project and make a comparison based on class standing and gender.

II. Background

Contemporary engineering students are under the expectation that they must have knowledge and skills regarding global collaborations. Such expectation has been urged by industry as well as society. Several institutions in Latin/South America have already began to answer the call to create an internationally prepared engineer. Institutions such as the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), the Ibero-American Science and Technology Education Consortium (ISTEC), the Asociación Ibero-Americana de Instituciones de Enseñanza de la Ingeniería (ASIBEI), and Engineering for the Americas (EftA) "….. promote the formation of world-class engineers for the Americas as well as an assortment of resources and opportunities that facilitate the participation of faculty, staff, and students from Latin America and the Caribbean in a variety of engineering education experiences" [12]. A collaborative network of institutions from the Americas and Italy has developed and executed collaborative multinational 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. However, a real challenge of this practice has been to create an effective interaction among the students participating in this type of projects and to maintain the flow of information, and student engagement in the project and in their learning [13].

Interest has been identified as part of motivation and there are several measuring tools to determine it: Work Preference Inventory (WPI), which is designed to assess individual differences in intrinsic and extrinsic motivational orientations [14]; and the Academic Motivation Scale (AMS), which has allowed researchers to distinguish relevant associations between motivation and academic variables [15]. A 24-factor scale of motivation is proposed in [16], with attitude items linked to behaviour items, based on a conceptual model of Motivation, involving Striving for Excellence (Standards, Goals, Tasks, Effort, Values and Ability), Desire to Learn (Interest, Learning from Others and Responsibility for Learning), and Rewards (Extrinsic, Intrinsic and Social). Motivation theories incorporate a wide array of contributing factors; modern theories most relevant to engineering pertain to goals, values, and expectations [17]. Value models of motivation [18], indicates that expectations of success and the value placed on success determine motivation to achieve, and directly influence performance, persistence, and task choice. It is evident that those who persist in engineering have different motivation profiles than those who do not [19]; a shift occurs in students' motivational profiles over the course of an academic year (i.e., decreased expectancy, increased future and present perceptions). Another research demonstrated that expectancy and future time perspective frameworks might be limited at identifying motivational differences between engineering majors [20]. Previous reports [21, 22] have linked interest (motivation) by students to participate in multinational collaborative design projects.

III. Proposed Approach

This study investigates possible differences in interest of participation by students in a collaborative multinational design project, with particular emphasis on the effect of students' class standing and gender. Interest was selected as indicator of motivation because it is one of the constructs typically used to evaluate motivation. The instrument used in this study is based on the Intrinsic Motivation Inventory (IMI). This is an instrument based on Self-Determination Theory [23], and it aims at assessing motivation in a broad array of situations and contexts. This instrument has been used for research focused on intrinsic motivation and self-regulation in many fields such as sport activities, reading, computer activities, performance on puzzles, and training and education. In all these studies, the IMI versions used varied in subscales and items depending on the characteristics of tasks and participants [24]. A version of IMI was designed for this study, consisting of 27 questions on five constructs: interest, perceived competence, pressure, perceived choice, and value. Data was compiled from the administered questionnaires. There were a total of 32 questions, five demographics questions and 27 IMI-based questions. The first five questions allowed characterization of the population participating in the study. The next 27 questions used a seven-point Likert scale and are distributed in five constructs, as follows: interest/ enjoyment (7), perceived competence (5), pressure/tension (5), perceived choice (5), and value/usefulness (5).

The multinational collaborative project assigned for this study follows the parallel project approach in which teams from different countries work on the same design project, and clusters of collaboration are formed for the international teams to exchange information and enrich the final design. Clusters are created in such a way that teams at each participating institution are assigned to clusters with teams from other countries, thus promoting exchange of information and collaborative work. Formal interaction of the students is expected to take place using the formal means of communication that have been established specially for the collaboration, which are audio-video conferences (Adobe Connect), email, and a cloud storage application selected for the project. Additionally, teams are allowed to use informal means of communication to keep the interaction active during the project, including social media, texting, cellular phones and other online communication tools as the teams consider appropriate. The projects last from four to eight weeks, depending on the term schedule at each participating institution, and clusters are required to have formal interaction for at least four weeks, which is when there are scheduled videoconferences. The task assigned as collaborative design project was the design of an appropriate workspace for prototyping with hand-tools. The following requirements were defined for the project: the workplace was to accommodate up to four people working simultaneously; workers with various types of disabilities should be able to use the facility; workbenches were to be utilized for prototyping and tools/materials storage; workbenches were to be installed in 34 m^2 room with the footprint of the workbenches limited to a maximum of 50% of the room space.

The objectives of this study are to determine the level of interest (or enjoyment) of students participating in the organized multinational collaborative design project, make a comparison of such interest between pre-participation and post-participation, and determine if there are any correlation between such interest and class standing or gender. In order to collect information from the students, the designed version of the IMI survey was administered to all the students before starting and after ending their participation in the collaborative project. The following research questions were addressed:

- Do students report high level of interest when they start/end their participation in a multinational collaborative design project?
- Is there a difference on interest by students before and after participating in a multinational collaborative design project based on their class standing?
- Is there a difference on interest by students before and after participating in a multinational collaborative design project based on their gender?

IV. Results

The data used for this study was collected during the collaboration project that took place for eight weeks between October and December during the Fall 2015. In this project there were 54 international teams from seven different academic institutions representing six countries (there were two institutions from the USA). The teams were grouped in twelve clusters, with six clusters having five international teams and six clusters having four international teams, as it is illustrated in Table I (there were two teams from Chile in each cluster). The representation by each one of the participating countries is given in Table II, where it is shown that there was a wider geographical representation in the PRE-survey, with four countries (i.e., Chile, Ecuador, Honduras, USA) having substantial number of students. The POST-survey was submitted mainly by students from two countries, Honduras and USA.

TABLE I
International Representation in Clusters

Cluster	Countries
1	Chile – Ecuador – USA1 – USA2
2	Chile – Ecuador – USA1 – USA2
3	Chile – Ecuador – USA1 – USA2
4	Chile – Ecuador – USA1
5	Chile – Ecuador – USA1
6	Chile – Ecuador – USA1
7	Chile – Honduras – Italy – USA1
8	Chile – Honduras – USA1 – USA2
9	Chile – Honduras – USA1 – USA2
10	Chile – Honduras – USA1
11	Chile – Honduras – USA1
12	Brazil – Chile – USA1

USA1: United States (University 1)
USA2: United States (University 2)

TABLE II
Geographical Distribution

Country	Number (PRE)	Number (POST)
Brazil	4 (2.2%)	2 (2.5%)
Chile	49 (26.5%)	1 (1.2%)
Ecuador	33 (17.8%)	0 (0%)
Honduras	28 (15.1%)	17 (21.0%)
Italy	4 (2.2%)	2 (2.5%)
USA	67 (36.2%)	59 (72.8%)
Total	**185**	**81**

The number of participants in the online questionnaires was 218 students for the PRE-participation and 87 students for the POST-participation. From those participating in the PRE, 185 surveys from six different countries were considered valid responses; and from those participating in the POST, 81 surveys from five countries were considered valid responses. The majority of the invalid surveys were incomplete ones, or surveys having the same numerical answer for all questions. Regarding class standing, the PRE and POST distributions are given in Table III. The data in the table shows that the groups with higher percentages are first-year students and fourth-year students in both surveys (24.9 % and 46.9% in PRE, and 28.6% and 27.2% in POST, respectively). In terms of gender, Table IV provides the distribution for each set of surveys, the participants were 87% male (N=161) and 13% female (N=24)

for the PRE group; and 82.7% male (N=67) and 17.3% female (N=14) for the POST group. Both distributions are typical, and therefore representative, of an engineering program.

TABLE III
Class Standing Distribution

Class Standing	Number (PRE)	Number (POST)
First Year	46 (24.9%)	38 (46.9%)
Second Year	44 (23.8%)	7 (8.7%)
Third Year	19 (10.3%)	12 (14.8%)
Fourth Year	53 (28.6%)	22 (27.2%)
Fifth Year of higher	23 (12.4%)	2 (2.4%)
Total	**185**	**81**

TABLE IV
Gender Distribution

Gender	Number (PRE)	Number (POST)
Male	161 (87.0%)	67 (82.7%)
Female	24 (13.0%)	14 (17.3%)
Total	**185**	**81**

The initial evaluation of the collected data is for consistency, hence a Cronbach's alpha analysis was conducted on the filtered PRE and POST data (Table V). It is observed from the result that, although the entire instrument has been already validated and is considered consistent, the interest construct being used in this study has an acceptable alpha index in both administered surveys (i.e., greater than 0.65, the minimum recommended), which makes the dataset reliable [25]. Once the responses for the interest construct were validated, the actual value of such construct is evaluated according to the following relationship:

$$Interest = S1 + S6 + S9 + S12 + S17R + S21 + S24$$

where each 'S#' corresponds to the survey question with that number (#), and the 'R' indicating that such survey question is a negative one, that is, it is in the inverse sense implying that its response value has to be reversed by subtracting its numerical answer from a value of eight (8). The maximum score for the construct is 49 points.

TABLE V
Results Cronbach's Alpha

	PRE	POST	Number Qs
All Constructs	0.856	0.786	27
Interest/Enjoyment	0.931	0.703	7

The research questions were analyzed utilizing the results from the questionnaires as follows:

- ***Research Question 1:*** *Do students report high level of interest when they start/end their participation in a multinational collaborative design project?*

Two hypothesis are formulated to test this question, the first one ($\boldsymbol{H_1}$) states that students start their participation in the multinational collaborative design project with high interest, and the second one ($\boldsymbol{H_2}$) states that students end their participation in the project with high interest. To measure if these hypotheses are true, the construct interest/enjoyment needs to be high as this subscale is considered the self-reported measure of intrinsic motivation in the IMI. Therefore:

$$\boldsymbol{H_1}: \mu_{Interest\ -\ PRE} \geq 70\%$$

$$\boldsymbol{H_2}: \mu_{Interest\ -\ POST} \geq 70\%$$

Based on the responses from both surveys, basic statistics are calculated and summarized in Table VI. According to the analysis, the students reported a high level of interest towards their participation in the multinational collaborative design project, with an average score of 76.6%. However, there is not such high level of interest after their participation in the project, with an average score of 58.8%. The PRE score can be explained based on the high expectation that represents participation in such projects, but the POST result indicates that the experience was not up to the students' expectations. Further analysis using a *t*-test between the PRE and POST sets indicate that the null hypothesis of similar means shall be rejected with a significance level of 0.05.

TABLE VI
Results Level of Interest - Hypothesis 1 and 2

	Average Score	Standard Deviation	Percentage (%)	Decision (α=0.05)
Interest PRE (H_1)	37.52	8.22	76.6	Retain hypothesis
Interest POST (H_2)	28.82	10.02	58.8	**Reject** hypothesis

- ***Research Question*** *2: Is there a difference on interest by students before and after participating in a multinational collaborative design project based on their class standing?*

The generic hypothesis formulated to test the research question states that there is no difference between the means of the two samples (null hypothesis) when students from each class standing report their level of interest. There are five different class standings allowed, from first-year to fifth-year student, therefore there are five different possibilities for the following hypothesis:

$$\boldsymbol{H_3}: \mu_{Interest\ (Class\#\ -\ PRE)} = \mu_{Interest\ (Class\#\ -\ POST)}$$

An independent-sample *t*-test was performed for each class standing in order to test if the hypothesis is true. A homogeneity of variances test (Levene) was performed on each one of the datasets used for the t-test, where a significance level of 0.05 is as well specified. The results from the *t*-test are summarized in Table VII, where it can be seen that, overall, there is a significant difference between the level of interest between PRE and POST data, with the main contributing factors being the significant differences that exists for the freshman (i.e., first-year students) and seniors (i.e., fourth-year students). These results are similar for equal

or non-equal variances, with the expected reduction in the level of significance (p) for the homogeneity of variances.

TABLE VII
Results Interest vs Class Standing - Hypothesis 3

Year	Time	Average Score	Standard Deviation	p (%)	Decision (α=0.05)
1	Pre	39.04	9.26	*0.000*	**Reject**
	Post	31.11	8.75		
2	Pre	38.45	7.3	0.213	Retain
	Post	32.9	11.2		
3	Pre	36.22	7.83	0.101	Retain
	Post	29.9	12.1		
4	Pre	36.74	7.65	*0.000*	**Reject**
	Post	23.45	8.75		
5	Pre	34.67	8.49	0.161	Retain
	Post	21.0	4.24		

- ***Research Question 3****: Is there a difference on interest by students before and after participating in a multinational collaborative design project based on their gender?*

The generic hypothesis formulated to test this research question states that there is no difference between the means of the two samples when students from each gender report their level of interest (null hypothesis). There are two genders reported, male and female; therefore, there are two different possibilities for the following hypothesis:

$$H_4: \mu_{Interest\ (Gender\ -\ PRE)} = \mu_{Interest\ (Gender\ -\ POST)}$$

As in the previous hypothesis, an independent-sample t-test was performed for each gender reported in order to test if the hypothesis is true. A Levene test for homogeneity of variances was performed on each one of the datasets used for the t-test, with a significance level of 0.05. The results from the t-test are summarized in Table VIII, where it can be seen that for both, male and female students, there is a significant difference in the level of interest between PRE and POST data. Consequently, there is an overall difference in interest between PRE and POST, which is statistically significant.

TABLE VIII
Results Interest vs Gender - Hypothesis 4

Gender	Time	Average Score	Standard Deviation	p (%)	Decision (α=0.05)
Male	Pre	37.09	8.34	*0.000*	**Reject**
	Post	30.43	9.34		
Female	Pre	40.48	6.82	0.000	**Reject**
	Post	20.79	9.73		
All	**Pre**	**37.52**	**8.22**	**0.000**	**Reject**
	Post	**28.8**	**10.0**		

V. Conclusions

This study reports on the comparison of level of interest reported by students before and after their participation in a multinational collaborative design project. A questionnaire based on the intrinsic motivation inventory (IMI) was designed, and it was administered to the students participating in the project. The comparison was done based on overall interest, class standing, and gender. According to the results of the study, the following may be concluded:

- students showed a high level of interest towards participating in the multinational collaborative design project, however there is decline in their interest after their participation
- based on class standing, there is a significant difference in the interest by students before and after their participation in the collaborative project, particularly for first-year and fourth-year classes
- based on gender, there is a significant difference in the interest by gender-specific students before and after their participation in the collaborative project, with similar result for the entire group of participants

These results are an indication that this particular collaboration was not as interesting as it was expected. It is accepted that there are several challenges whenever this type of learning activity is conducted, and the authors feel that most of them are addressed but the significant differences indicate otherwise. The level of expectations, perhaps fuelled by incomplete or erroneous information regarding the collaboration might be the main contributing factor. However, there are several other reasons that can be listed to explain the results, and after some thinking, it can be said that logistical challenges and project formulation are at the top of the list.

Some specific interventions will be implemented in future offerings of this academic experience. Among them: a) better information regarding expectations from the collaboration, b) less rigorous exchange of information, and c) project task that offer something of interest to all students. Additionally, there will be a survey with specific questions regarding the students' opinions and beliefs about the experience.

Faculties are conscious of the challenges that globalization poses to current business endeavours, and knowledge and skills to overcome those challenges is something that needs to be provided to the students. The implementation of a learning experience with multinational collaboration is the goal that is being pursued, and the authors plan to keep working on it.

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