

Comparison of Intrinsic Motivation of Freshmen Engineering Students as they Participate in a Multinational Design Project

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Abstract

Incorporation of collaborative multinational global design projects into engineering courses early in the curriculum has the purpose of not only highlighting the significance of professional competencies but also creating a learning experience where students can start developing those skills. Therefore, of particular importance is to determine the intrinsic motivation, as indicated by interest and perception of value, which students have about a collaborative multinational design projects introduced in the first year. This paper presents the results of an evaluation aimed to determine the level of those constructs, interest and perception of value that a group of students in US institutions have when participating in a collaborative multinational design project. The evaluation was done with a questionnaire based on the Intrinsic Motivation Inventory (IMI) and was given to the students at the beginning and at the end of their participation in the multinational design project. The complete set of data collected provides information in five sub-scales or constructs, with only two of them included in this comparison due to their direct influence on students' beliefs and feelings about the international project and, consequently, in the motivation of students on this learning experience. The results show a statistically significant change in the level of intrinsic motivation that is contrary to the educational intention of the learning experience. Such difference follows the same trend that their international counterparts, but at larger scale. Possible causes and recommendations are provided as part of this work.

Introduction

There is an increasing need to prepare future engineers with technical and professional skills to be competitive in the global market. Technical knowledge has been traditionally taught in an effective way but the professional skills had been placed in a second tier. This has been the trend until the new global economy and information technology developments started calling for engineers with traits and abilities beyond the technical knowledge. Teamwork, communication, and global awareness skills are now essential topics in the engineering curriculum. As a result, students are exposed to educational experiences where such competencies can be developed. However, the effectiveness of those educational experiences is closely related to the level of interest and perception of value that students have regarding those experiences as supported by studies reported in the literature. Intrinsic motivation is an important driver contributing to the learning process. In the case of engineering, students can appreciate the technical aspects of their career, nevertheless, they might not easily recognize the value of teamwork, communication, and global awareness competencies in an engineering environment.

Therefore, collaborative design is increasingly becoming a central activity in the development 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 collaboration between diverse parties. Working on a collaborative environment provides the advantages of having complementary resources, information and ideas that compensate for the limitations of a design done individually. The expected result is a product that could not have been achieved by any individual acting alone, and such realization is a goal when involving US students in a global project. The surge of information technologies, in particular communication capabilities – personal and professional - improve the capacity of sharing information across teams of designers located around the world, and provides the infrastructure necessary for an integrated and distributed engineering environment [Pfleeger and Atlee, 1998]. However, working on multi- or inter-disciplinary projects is inherently challenging, and effective collaboration may require new ways to share information. The challenges that are faced are cultural and educational ones, including logistics related to language and time zones [Torlind, 2016]. 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 [DeVoss et al., 2002], which has resulted in an increase in the number of educational experiences for current students.

In the academic environment the challenge consists in offering experiences to the students that will, first, made them aware of the required skills for multinational collaborative projects, then guide them in navigating such challenges, and finally have the experience wrapped up in the context of engineering project. One goal is for the students to acquire the skills necessary to operate in an interdisciplinary and intercultural collaborative environment. Many engineering programs in the US, and all around the world, are incorporating educational experiences to prepare students for the global working environment. Multinational collaborative design projects are one good example of those experiences incorporated through engineering curricula to promote the development of the global and cultural competencies in students, besides the technical knowledge of a technical discipline. These projects are established with teams geographically distributes but working on a common design project, and is under one such implementation that this study looks at the US students [Esparragoza et al, 2015]. The expectation when this project was introduced was to offer an international project with new opportunities for diversification and expansion, implying new challenges because of the new environment being introduced, with differences and similarities in culture, management, and economic aspects [Berteaux, 2015]. Thus, the collaborative multinational design project offering the students experiential learning that will prepare them to understand and face those challenges.

Background

In order to succeed in an academic endeavour, and for that matter in any undertaking in life, it is a key factor to have the proper level of motivation. This is particularly true in practical experiences such as international collaborative projects where students must be motivated to spend time to share ideas and information, and to do teamwork with colleagues from abroad.

These activities need to happen even when there is no explicit or immediate assessment performed, meaning that is not a specific activity that has been assigned. That is, students have to be intrinsically motivated, implying that their source of motivation is in the performance of the task itself [George et al., 1996]. In this case the design project itself should be such that students feel intrinsically motivated to behave in proactive, open minded and collaborative manner, 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 [Sheppard et al, 2010], and it is important to consider how to best support early year engineering students' motivation and self-regulating learning [Nelson et al, 2015], due to the fact that in these years is when students are more likely to drop out [Gainen, 1995].

There are many studies regarding the variety of factors, internal and external, that might affect motivation in an individual. In fields closed to engineering and applicable to engineering students, list goals, value, and expectations as relevant factors [Svinicki, 2004]. In the specific factor of value, reports mention that it is closely linked to success, indicating that expectation of success and the value that is placed on success are determinant factors of motivation, and indicate the desire to achieve something, which directly influence the performance, persistence, and choice of activity [Eccles et al, 1983]. Another research demonstrated that expectancy and future time perspective frameworks may be limited at identifying motivational differences between engineering majors [Jones et al, 2009]. An interesting conclusion in several reports dealing with students is that the motivation profile of those students pursuing an engineering program is different from those that do not have such inclination, without significant differentiation among majors or gender [Benson et al, 2013]. This last study has a more direct impact in the objective of the study presented here because it deals with first-year students, and brings as well the issue of external factors.

Methodology

The objective of the present report is to do a comparison in terms of interest and perception of value by first-year students from the US participating in a collaborative multinational design project. Both of those factors are latent constructs and are used as indicators for intrinsic motivation, which will be measured before and after the project is conducted. In order to have a complete description of the students' intrinsic motivation, a survey based on the Intrinsic Motivation Inventory (IMI) [Deci and Ryan, 2000] was developed and administered to the students to capture their self-reported motivation. The used instrument was developed by selecting questions from the complete IMI on five specific constructs for motivation [Monteiro et al., 2015]: interest, perceived competence, pressure, perceived choice, and value. There were 27 questions (i.e., statements) selected and they were adapted for the collaborative multinational project. The answers by the students to all of these questions follow the Likert scale (0 to 7 values), and some of the statements have reverse values, i.e., the specific construct is measured in a negative context. In addition to the 27 motivation-related statement there are four questions regarding to demographic information of the student.

Regarding direct measurements for this study, the administered survey has seven statements (one of them as reverse statement) in the interest/enjoyment construct, and five statements in the value/usefulness (none as reverse one) construct. Additionally, the pressure/tension construct has five statements (two of them reversed), the perceived competence has five statements (none of them reversed), and the perceived choice has five statements (three of them reversed). Even when the emphasis was placed on the interest and the value constructs, all five constructs were utilized to have a full indicator of intrinsic motivation.

The academic activity for this study was a collaborative multinational project that took place during the October – November 2015 period of time, that is the Fall 2015 semester in the US. There were 54 international teams from 6 countries (Brazil, Chile, Ecuador, Honduras, Italy, and USA), and they were assigned to 12 clusters. The project consisted on designing a prototyping workspace to be used by used simultaneously by 4 people, and it needs to consider people with disabilities; additional design requirements and constraint were provided to the teams according to local needs. The students participating in this project are not all first-year students, therefore the actual objectives of the project were established by each institution, with the requirement of having five weeks of interaction and collaboration with the clusters. Additionally, the school calendars are not all the same, reason why specific weeks were selected for the collaborative project. It is of interest to note that this collaborative academic activity has been in place for several sessions before this particular time period, and the previous two situations have been the results of the growth and molding that has taken place in order to have a better experience for the students. As well, based on the work that has taken place to improve the offering, this was the first semester when surveys were administered in order to collect data regarding motivation.

The objective of this study was to measure and compare the level of intrinsic motivation – as measured by interest and perception of value - of students participating in a multinational collaborative project. The comparison is between their motivation before and after their participation in the academic activity, there is no comparison between participation and no-participation since the project was part of a course for all participants. The following objectives were established:

1. Determine the level of interest of US students participating in the collaborative multinational design project, before they enter and after they finish their participation
2. Determine the perception of value of US students participating in the collaborative multinational design project, before they enter and after they finish their participation
3. Determine if there was change in the level of interest and the perception of value of the US students participating in the collaborative multinational design project.

Results

All the students participating in this design project had the opportunity to take the survey. The survey was administered online the week before the students started their participation in the project, and during the week after they ended their participation. The demographic information is tabulated below (Table I). There was a total of 218 students participating in the project and only

a portion of them submitted a valid survey, 164 (75%) on the Pre(-participation) and 84 (39%) on the Post(-participation); indicating a large decline overall in Post surveys. In terms of geographic distribution, 46 (28%) of the Pre surveys were from the US, and 59 (70%) of the Post surveys were from the US; indicating an increase in the participation from US students in the Post, and most of the Post results were from the US. The breakdown based on gender for the US students has a 89% male and 11% female for the Pre, and 88% male and 12% female for the Post; those staying constant and within the typical ratios in engineering.

All the collected data was initially checked for internal consistency and reliability, even when the IMI survey has been thoroughly tested and validated. This was done because the statement used in the developed survey had to be adapted to the particular academic activity of this study. A Cronbach's alpha analysis was performed on the two constructs considered in this study (interest and value), which resulted in acceptable values for both of them (values basically higher than 0.85, which is above the accepted minimum value), as reported in tables below.

Table I. Summary of Demographic Data.

Concept	Before	After
Total Number of Students	218	218
Valid Submitted Surveys	164	84
	75%	39%
Valid US Surveys	46	59
	28%	70%
Male	41	52
	89%	88%
Female	5	7
	11%	12%

For the actual study, hypotheses were established in order to evaluate the objectives mentioned in the previous section:

1. For the *first objective*, which investigates if the US students enter the Collaborative Multinational Design Project (CMDP) with a level of interest above 70% of the maximum possible score for such construct, therefore the Null Hypotheses is:
 - $\mu_{Interest\ CMDP} \leq 70\%$
2. Similarly, the *second objective* investigates if the US students enter the collaborative multinational design Project (CMDP) with a perception of value above 70% of the maximum possible score for such construct, therefore the Null Hypotheses is:
 - $\mu_{Value\ CMDP} \leq 70\%$

The maximum scores are based on the number of statements included in the particular construct, therefore, the interest construct has a maximum total of 49 points (i.e., 7 statements with a maximum score of 7 for each), and the value construct has a maximum score of 35 points. Because of the existence of reverse statements, the actual score for each construct was calculated based on the following expressions:

$$Interest = \frac{S6 + S11 + S14 + S17 + (8 - S22) + S26 + S29}{49}$$

$$Value = \frac{S10 + S15 + S19 + S24 + S32}{35}$$

where S## is the score given by each students to that statement number (##) in the administered survey. In the case of a reverse value, the (8-score) is utilized.

Table II. Summary of Results for First and Second Objective

Variable	BEFORE							Threshold Value (70%)
	N	Cronbach	Mean	SD	%	p-value	Decision	
Interest/Enjoyment	46	0.945	38.283	9.325	78%	0.0029	Reject Ho (Above 70%)	34.3
Value/Usefulness	46	0.849	30.826	4.040	88%	0.0000	Reject Ho (Above 70%)	24.5

Variable	AFTER							Threshold Value (70%)
	N	Cronbach	Mean	SD	%	p-value	Decision	
Interest/Enjoyment	59	0.943	27.339	10.350	56%	1.0000	Do Not Reject Ho (Below 70%)	34.3
Value/Usefulness	59	0.897	23.068	7.039	66%	0.9382	Do Not Reject Ho (Below 70%)	24.5

Table II summarizes the results for this first objective of measuring levels of interest and value. The analysis indicates that, before their participation:

- US students considered that their interest in participating in the CMDP was high
- US students considered that the value of participating in the CMDP in their education was high

and after their participation:

- US students considered that their interest in their participation in the CMDP was low
 - US students considered that the value of their participation in the CMDP in their education was low.
3. For the *third objective*, which evaluates if there was a significant change in the measured constructs, before and after participation, the following Null hypotheses were formulated to evaluate each construct:
- $\mu_{Interest\ Before\ CMDP} - \mu_{Interest\ After\ CMDP} = 0$
 - $\mu_{Value\ Before\ CMDP} - \mu_{Value\ After\ CMDP} = 0$

Table III summarizes the results for the comparison before (Pre) and after (Post). From the results. i.e., reject the null hypothesis it can be concluded that there is significant differences between the results, thus indicating that there is a significant change in the intrinsic motivation of the students as they participate in the academic activity (CMDP).

Table III. Summary of Results for Third Objective.

CHANGE								
Test	Variable	n	Cronbach	Mean	SD	%	p-value	Decision
Before	Interest/ Enjoyment	46	0.945	38.283	9.325	78%	0.0000	Reject Ho (Significant Difference)
After		59	0.943	27.339	10.350	56%		
Before	Value/ Usefulness	46	0.849	30.826	4.040	88%	0.0000	Reject Ho (Significant Difference)
After		59	0.897	23.068	7.039	66%		

Basically:

- There was a significant decrement in the interest of students participating in the CMDP
- There was a significant decrement in the perception of value in their education of the students participating in the CMDP.

Conclusions

Based on the results obtained for each one of the objectives established for this study, it can be concluded the following:

- students from the US participating in the academic activity have a high level of motivation before participating in a collaborative multinational design project, as measured by the level of interest and value that they reported in an IMI-based survey;
- students from the US participating in the academic activity have a low level of motivation after participating in a collaborative multinational design project, as measured by the level of interest and value that they reported in an IMI-based survey;
- the changes in the US students' motivation are statistically significant.

Additional evaluations were performed on the data collected with the aim of better understand the results presented. The first analysis measured intrinsic motivation using all five constructs that had been utilized in the designed survey, and the results were similar to the ones reported above (i.e., significant decrease in the level). Another evaluation was on the results for non-US students, even with the reduced number of responses in the data, with once again similar results, but with smaller changes.

Certainly, these results were opposite to what it was expected from the academic activity, but at the same time there were very revealing results. The decrease in student motivation had negative connotations in the learning experience since the goals were not been reach and, in the particular case of US students, who are the main focus of this study, could have a possible impact in retention. A similar thinking was developed by the faculty from the participating institutions, and that is that perhaps the excitement and interest from the students for an international collaboration was overwhelming the fact that there are issues and challenges that need to be overcome. Based on the results, the faculty involved in the CMDP have defined interventions in the manner the activity is conducted. These interventions have the objective of taking into account aspects related to the project itself (e.g., attractive project), the way the collaboration is taking place (e.g., greater emphasis on communication), and external factors (e.g., consideration to local non-technical challenges). Some of these modification are being implemented, and the results will be reported in the future.

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