

Study on Interest and Perception of Value in Multinational Collaborative Design Projects Among Engineering Students

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Abstract. The level of interest and perceived value of engineering students in a multinational collaborative design project experience is reported in this paper. The report establishes a comparison based on geographical location and class standing of the participants. For this purpose, a survey was used to collect demographic data and students' feedback on questions based on the Intrinsic Motivation Inventory (IMI) survey, which permits to evaluate five constructs, being interest and perceived value the ones considered in this work as indicators of motivation. The data was collected from students participating in the collaborative design project. These students were at seven institutions in six countries (USA, Honduras, Ecuador, Brazil, Chile, and Italy). The analysis of the data collected shows that students have a high level of interest and value the experience, with some numerical differences based on geographic location and class standing, but only significant difference based on class standing. These results are of importance when considering multinational collaborations in a generation of students moving towards a smart society, indicating a level of motivation that is mainly affected by academic maturity.

Keywords: Multinational projects · Interest · Value · International collaboration

1 Introduction

For many years instructors have discussed the advantages and disadvantages of inductive and deductive teaching and about which of these two methods is better for students' learning. The literature on this topic is ample as well as the research work and the experimental studies about it [1, 2]. The progress in education has led to teaching methods increasingly tailored to satisfy the needs of specific topics of study, and new

questions about effective educational approaches are flourishing daily, particularly when smart society is considered, demonstrating that education research is an alive field in constant development and evolution [3, 4].

The development of new educational methods has been favored by the existing awareness that, in order to obtain a deeper understanding - conceptual and functional - of the material proposed to the students, the material itself has to be presented in an adequate form and students have to be engaged and motivated on activities able to integrate theory and practice. The aim of all such activities is to reduce the boredom of the students and move the knowledge they have acquired from a superficial level to one of a greater awareness, inducing new motivations in the students. For this to happen, students have to be actively engaged into constructing their own experiences, similar to what happens during laboratory testing in scientific disciplines. It is proven that when the learning is situated in a real context, the capacity to acquire the meaning of the phenomena observed is greater [5].

One of the most widespread learning methods is Project Based Learning (PBL) that proposes the involvement of students in activities very similar to those they will face in their professional life, offering them the opportunity to be engaged in the development of a feasible solution to a real problem. The PBL method allows students “to learn by doing and applying ideas” [6]. In this learning methodology, students are called to find solutions to driving questions while collaborating in teams under instructors’ supervision. Such pedagogical approach has been incorporated in courses at all educational level and it has become widely accepted and applied in the academic setting. This is due not only to the fact that the methodology facilitates the learning experience of a subject by getting immerse in the solution of the problem, but also because of the ability that the method has to increase students’ professional skills. These competencies, known as Dublin’s descriptors and considered fundamentals for forming the European students [7], include knowledge and understanding (fundamentals and application), the capacity of learning and communication skills, and the ability of making an autonomous judgement, all of which can be gained through PBL.

Today’s society is demanding that the people that will be in the working force of tomorrow’s world be prepared and ready to be productive in the expected smart society. In a global business environment, there is the expectation that all members of a professional workforce have a set of global competencies that will make them more productive. Globalization is constantly changing various aspects in society, particularly the process of knowledge creation and dissemination [8]. The formation of multinational partnerships is a common practice in the corporate world nowadays, with the aim of taking advantage of a diverse and rich knowledge platform dispersed throughout the world. Geographically spread teams are now working together not only to create new products but also to discover solutions to great global challenges. These multinational teams are being supported by rapidly growing information technology capabilities, which facilitate their creation and functionality, one of the foundations for a smart society. Hence, modern competitiveness around the world requires preparing professionals who are able to face all sorts of technical endeavors by sharing their competencies in global environments and through the use of virtual tools. As a result, there is a growing demand to prepare professionals to be ready to perform in multinational environments. The engineering education should not be solely focused on preparing

students to solve local or national issues, but also in educating world-class engineers capable of working as well on global challenges. Similarly, globalization has resulted in many companies having operations in several countries, so engineering students should also be prepared to work in global projects with multicultural teams.

In response to the demands for global professional skills, a PBL educational activity engaging students in multinational teams located in different countries has been adopted by several institutions in order to improve students' collaborative and communication skills in an international and diverse setting. Such a study is the core of the project presented here. However, the effectiveness of this practice had not been rigorously evaluated until recently when formal studies of different aspects of this practice were initiated. The aim of these studies was the improvement of the students' learning experience to attain the desired goals. Initially, the interaction among the participants was studied by the authors and identified as an important issue for the success of the practice [9]. That work led to new questions to understand better the behavior of the students during their involvement and interaction in the collaborative project. One of these questions was related to the motivation that students had about this practice. Based on a literature review, it can be stated that motivation is an important factor that includes interest, which is an important construct that contributes to the learning experience [10]. In the particular case of engineering, some efforts have been done to evaluate and enhance motivation in the students [11] with the aim not only of succeeding in specific topics but also to enhance students' self-efficacy and self-confidence in the field [12–14].

This paper presents the results of an evaluation to determine the level of interest and perception of value of students participating in an engineering multinational collaborative design project. These constructs were used to evaluate the students' motivation when given the opportunity to participate in such multinational project. The comparison presented is based on geographical location and class standing, which are demographic characteristics that the authors believe have a direct influence in the students' motivation. The evaluation was done with a survey administered to more than 200 students at seven institutions in six different countries, and students from five levels of academic experience.

2 Background

2.1 Motivation, Interest, and Self-efficacy

Motivation involves internal processes that activate behavior's persistence, energy, direction and excitement, and originates from a variety of sources, such as needs, cognitions and emotions, and these internal processes energize the behavior in multiple ways [15, 16]. Jones [17] defines academic motivation as physical activities and a mental disposition directed toward specific objectives that can be sustained in time, concluding that it is important in education because it engages students in the learning activities and helps them to reach high academic goals. It has been reported that motivated students tend to pay more attention to coursework, take time to use effective learning strategies, and look for help from others when necessary [18]. Weber [19]

established a strong correlation between interest and intrinsic motivation in students determining that intrinsic motivation is an important driver in students learning while the external motivation is not. This agrees with the assertion from Hidi and Renninger [20] who state that interest includes situational interest (immediate, short-term enjoyment of instructional activities) and individual interest (internally activated personal values about a topic) that tends to be more lasting. In their case, the individual interest is related to intrinsic motivation while situational interest is closer to external motivation.

Alexander et al. [21] established the relationship between interest and learning. In such work, it was concluded that students interested in a subject would learn it better than students not interested would. Therefore, the relation between motivation, interest and academic success is strong [22]. The academic motivation is directly and indirectly influenced by the learning processes [23]. The usefulness component of an educational model relates to the degree to which students believe course activities have value for their goals [24]. Therefore, it is important that all learning activities are prepared to stimulate the motivation for the subject in students because it is necessary to trigger the interest in all learning activities [25]. Another key element in students' continuous progress and retention is steady development of self-efficacy. According to Bandura [26] self-efficacy can be defined as one's perception of capability in organizing and executing actions that accomplish desired tasks. It was determined that the course of action that people chooses to follow is influenced by their self-efficacy. Likewise, the amount of effort put forth into a specific task and the level of perseverance are also affected. Thus, educators in general are emphasizing the importance of understanding the methodologies employed to enhance self-efficacy [27].

2.2 Project-Based Learning

In recent years, teaching and learning methods at the university level have experienced a transformation aimed to increasing active learning in the classroom [28]. The concept behind this learning method is to connect students directly and engage them actively in the learning process. The Project Based Learning (PBL) method, is one of the most effective ways to engage students with learning content and is strongly recommended by several educators as one of today's best education practices [29]. In the PBL, the learning process is centered on the student who works in a group project to solve a real situation proposed by the instructor. Another characteristic of the PBL is that in the projects, students engage in a constructive investigation that involves inquiry, knowledge building and resolution. Therefore, PBL challenges students with real problems, promotes collaboration among students in conducting their investigations, and encourages students to incorporate and fuse their knowledge in order to solve the presented problems. While working on these projects, students develop cognitive tools that facilitate future learning [30–32].

Several advantages in student learning were related to PBL as motivation to work hard, responsibility, maturity, proactivity, better preparation for professional life, learn to learn, learn to work to agreed deadlines, communication skills, higher level thinking skills, new learning resources, variety of learning styles [33, 34].

Realistic and authentic engineering experience gained through PBL aims to expedite a sense of domain mastery leading to increase in self-efficacy in engineering field. Close relation between self-efficacy and motivation has been observed, as students' motivation grows with their confidence in their ability to accomplish successfully assigned tasks [35]. The tasks should be challenging but not perceived to be beyond capability. One might comprehend the task to be beyond his/her capacity and deviate from the task in favor of activities perceived as more rewarding, or easier to accomplish. However, establishing sub-goals for a complex distant goal might be perceived to be within one's level of self-efficacy. Sub-goals set correctly, when accomplished, can increase self-efficacy by mastering sub-activities. This will lead to greater students' commitment to complex distant goals.

According to Ponton et al. [36], there is a close interrelation between self-efficacy, cognitive motivation and valuable outcomes. This relation determines the type of actions followed by each individual to reach the desired outcomes. This is very important when an educational experience is introduced in the classroom and it is expected students take full advantage of it. However, characteristics of people such as feelings, opinions or attitudes are known as latent constructs, which are unobservable traits that cannot be observed directly, and need to be measured through indicators that can be captured in a scale format [37]. Therefore, the students' interest and perception of value for multinational collaborative design projects have to be measured through an instrument based on scaled indicators.

2.3 Collaborative Projects

A group of institutions in the Americas and Italy has used for several years multinational collaborative design projects as part of their engineering education experience with the aim to foster global competencies in engineering students. These projects are in-class and same-term assignments that usually last eight weeks and bring together groups of students from different countries to work as a team in a design challenge. Teams of students are formed at each participating institution and clusters of teams are formed internationally to promote interaction as well as exchange of information and ideas while working on a solution for the problem assigned. All teams receive the same design project in the different institutions. Students are asked to work with the other teams in their cluster by using formal tools for communication (i.e., email, web-based meeting rooms for audio-video conferences, and platform to exchange files), but are also allowed to use informal tools for social interaction (e.g., social networks) to build trust and enhance the overall interaction among the international teams.

The challenges faced by students in these collaborations are not trivial ones because those include aspects such as differences in language, culture, and educational background, as well as the requirement to work across different time zones [38], with all of them representing typical competences required by today's companies from their professional workforce [39]. Besides, students are also required to develop their capacities to use information and communication technology tools to share information with their international partners.

This type of experiences became a test rig to understand the most suitable mechanisms to allow a better involvement of students and to improve the effectiveness of such pedagogical methodology. One of the most critical questions about this educational activity is the one related to the students' motivation and interest in participating since these aspects are critical to the success of this academic experience. In fact, the relevance of the information shared among the cluster of teams and their interaction are conditioned by the desire of any single student to participate in the activity. Additionally, motivated students will have the disposition to overcome the project difficulties, and recognize the value of the experience for their professional future.

The work presented here is a novel effort to assess the level of motivation self-reported by students when they are assigned the multinational collaborative design project. Even though there are different instruments that capture different factors to determine the level of motivation showed by an individual [40], the Intrinsic Motivation Inventory (IMI) [41] provides the set of questions to capture interest, perceived competence, pressure, perceived choice, and value. Two of these constructs are used in this study to evaluate motivation level in a multinational collaborative design project.

3 Objectives and Research Questions

Results from previous work [13] led the authors to believe that motivated students will:

- (a) have the interest necessary to get immerse in a project;
- (b) have the disposition to overcome difficulties in the development of a project - including broken communication, level of commitment, and cultural barriers;
- (c) recognize the value of the PBL multinational experience.

If those elements are present, then it is expected that students will enhance their confidence when undertaking collaborative multinational design projects, perform better in the tasks, including effective teamwork and communication, and appreciate the global experience. Therefore, the aim of this work is to evaluate the interest and perception of usefulness of assigned collaborative multinational design projects in engineering students at different locations in the USA, Latin America and Italy, and with various class standings. The purpose is to have an understanding of those critical factors to answer the following research questions:

1. Do students enter into the multinational collaborative project with a high level of interest and a high perception of value for this activity?
2. Are there significant differences on interest and perception of value among the students based on their geographical location, or class standing?

4 Methodology

Since the purpose of this study is to evaluate interest and perception of value of an academic activity, both of which are latent constructs that cannot be measured directly or objectively, a survey based on the Intrinsic Motivation Inventory (IMI) [13] was

used to capture students’ perception before their participation in the multinational collaborative design project. This is a deductive and descriptive study that captures qualitative data through a survey to quantify it (i.e., mixed methods). The first four questions in the survey are about demographics that will help to compare the answers based on student location and class standing, among others. Then, 27 statements are given and students are asked to give their personal level of agreement to those statements. These 27 statements were selected from a full IMI survey, and modified to relate specifically to the collaborative design project. Their answers are based on a Likert scale ranging from one to seven, where one is “not at all true” and seven is “very true”. Those 27 statements are distributed into the five constructs for motivation defined by Deci and Ryan [42]: interest/enjoyment (7 statements), perceived competence (5 statements), pressure/tension (5 statements), perceived choice (5 statements), and value/usefulness (5 statements). The five motivation constructs are to be measured and calculated as described in Table 1. The average value of each survey items should be added accordingly and in the case of the reverse values (indicated as “R” in the Table), these are to be calculated by subtracting 8 to the measured values.

Table 1. Survey items and motivation building constructs.

Construct measured	Survey items used
Interest/Enjoyment	1, 6, 9, 12, 17(R), 21, 24
Pressure/Tension	2(R), 7, 11(R), 16, 22
Value/Usefulness	5, 10, 14, 19, 27
Perceived competence	4, 8, 15, 20, 26
Perceived choice	3, 13(R), 18, 23(R), 25(R)

Since the survey used was constructed from the IMI, which has been thoroughly tested [42], it is not necessary to perform a factor analysis of each construct. However, the reliability and internal consistency of the complete instrument and the individual constructs need to be assessed through a Cronbach’s alpha analysis. If Cronbach’s alpha values superior to 0.7 are achieved the instrument and constructs can be considered reliable [43], otherwise adjustments must be made in the corresponding low-score factors in order to obtain the reliability and consistency required. Finally, using the results from the survey, the specific construct values can be measured and the corresponding analysis can be performed.

Considering that studies have shown that hands-on classes (i.e., active learning) which are highly aligned with what industry are currently demanding increase the level of motivation of students [44], it is fair to assume that a course centered around a multinational collaborative design project would be highly motivating for students. Similarly, it is also fair to assume that students would consider that a class activity teaching them how to deal in such type of environment would be highly useful for them in their professional formation. This is because globalization is an evident trait in our current market, and students, regardless of their geographical location or class standing, are aware that the most successful corporations are multinational with branches and operations throughout the world.

To test the first research question posed, the following hypotheses are stated:

- H_{1a} :** Students enter into the multinational collaborative design project with a high level of interest.
- H_{1b} :** Students enter into the multinational collaborative design project with the belief that the experience will be of value for their career.

Both of these hypotheses will be tested using a t-student unilateral test with respect to the 70% value of the maximum motivation possible, according to the construct measurement.

To test the second research question, the following hypotheses are stated:

- H_{2a} :** Students enter into the multinational collaborative design project with a similar interest regardless of their geographic location.
- H_{2b} :** Students enter into the multinational collaborative design project with similar interest regardless of their class standing.
- H_{3a} :** Students enter into the multinational collaborative design project with similar beliefs regarding the value of the experience for their professional career regardless of their geographical location.
- H_{3b} :** Students enter into the multinational collaborative project with similar beliefs regarding the value of the experience for their professional career regardless of their class standing.

These hypotheses were tested using analysis of variances test (ANOVA) comparing the responses for location and class standing.

5 Results

From a total of 218 surveys submitted by students participating in the global collaborative project, 182 were completed correctly (83% response rate). The survey was designed online and students completed the questionnaire before they started the project. Students were told that their participation was anonymous, voluntary, that their participation would not affect their academic evaluation, and that all information would be confidential. The survey was administered in English.

Descriptive statistics were performed using standard statistics software. From a preliminary analysis, it can be seen (Fig. 1) that there was a higher percentage of participation from first, second and fourth year engineering students. Also it can be seen (Fig. 2) that the gender of participants is in line with typical breakdown in engineering [45], and the distribution per country is presented in Fig. 3.

A Cronbach's alpha analysis was performed in each of the constructs and the complete instrument and it was found that the "Pressure/Tension" and "Perceive Choice" construct were below the 0.7 threshold value. The analysis showed that removing questions 16, 18 and 23 would improve the reliability of the instrument. This reduction was performed, even when the constructs considered in this study are interest/enjoyment and value/usefulness. As it is shown in Table 2, after the reduction was performed, acceptable alpha values were achieved for each construct and for the complete instrument.

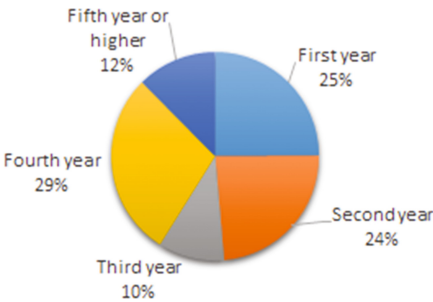


Fig. 1. Class standing distribution

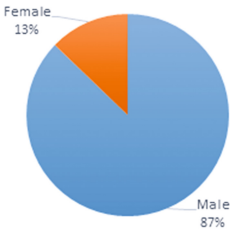


Fig. 2. Gender distribution

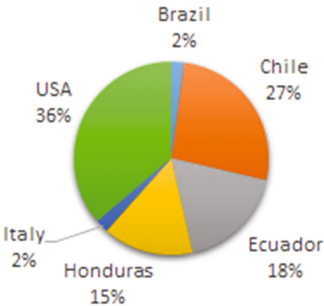


Fig. 3. Geographical location distribution

Table 2. Cronbach’s alpha results

Scale	Cronbach’s Alpha	No. of items
IMI instrument (all data)	0.856	27
Interest/Enjoyment	0.931	7
Pressure/Tension	0.752	5
Value/Usefulness	0.884	5
Perceived competence	0.828	5
Perceived choice	0.728	5

For the first research question (i.e., level of interest and perception of value), H_{1a} and H_{1b} were tested. To measure if H_{1a} was true, the variable “Interest/Enjoyment” needs to be high, as that subscale is considered the self-report measure of intrinsic motivation in the Intrinsic Motivation Inventory (IMI). This was measured in the following way:

$$H_{1a} : \mu_{Interest} \geq 70\%$$

where:

$$Interest = \frac{Q1 + Q6 + Q9 + Q12 + (8 - Q17) + Q21 + Q24}{49} \times 100\%$$

To measure if H_{1a} was true, the variable “Usefulness/Value” needs to be high. This was measured in the following way:

$$H_{1b} : \mu_{Value} \geq 70\%$$

where:

$$Value = \frac{Q5 + Q10 + Q14 + Q19 + Q27}{35} \times 100\%$$

According to the performed evaluation, both hypotheses were confirmed true as students displayed a high level of intrinsic interest towards their participation in the multinational collaborative design project, and the majority of students expected this experience to be of great value for their education. As it can be seen in Table 3, this is concluded based on the average overall scores collected from the survey (74.5% of the maximum possible score in the interest construct and 83.1% of the maximum possible score in the expected value) and their p -value < 0.05 , which rejects the null hypothesis and supports the proposed hypothesis. As additional information, it was also notable the low level of pressure they expected to experience for participating in the program (54%) and the high level of preparedness (competence) they felt they already had to undertake the collaborative design project (73%).

Table 3. Test statistics for Hypothesis 1 (interest and value high)

Variable	Avg. score	Stand. dev.	p -value	Conclusion
Interest (H_{1a})	74.5	18.1	0.000	Do not reject hypothesis
Value (H_{1b})	83.1	14.7	0.000	Do not reject hypothesis

For the second question, i.e., effect of geographical location and class standing on interest and perceived value, H_{2a} and H_{2b} were tested to see if there were significant differences in the interest of the students based on geographical location and class standing by using an ANOVA test. Then, this was measured in the following manner:

$$H_{2a} = \mu_{Interest(BRA)} = \mu_{Interest(CHI)} = \mu_{Interest(ECU)} = \mu_{Interest(HND)} = \mu_{Interest(USA)} \\ = \mu_{Interest(ITA)}$$

$$H_{2b} = \mu_{Interest(Y1)} = \mu_{Interest(Y2)} = \mu_{Interest(Y3)} = \mu_{Interest(Y4)} = \mu_{Interest(Y5+)}$$

Similarly, H_{3a} and H_{3b} were tested to see if there were significant differences in the value of the activity based on geographical location and class standing by using an ANOVA test. Then, this was measured in the following manner:

$$H_{3a} = \mu_{Value(BRA)} = \mu_{Value(CHI)} = \mu_{Value(ECU)} = \mu_{Value(HND)} = \mu_{Value(USA)} = \mu_{Value(ITA)}$$

$$H_{3b} = \mu_{Value(Y1)} = \mu_{Value(Y2)} = \mu_{Value(Y3)} = \mu_{Value(Y4)} = \mu_{Value(Y5+)}$$

Using the results from the administered survey, the results are summarized in Table 4. As it can be observed in the table, in the case of the geographical location, the interest of students towards the multinational collaborative project and their belief regarding its value for their professional career show no significant differences in all countries involved. In the case of class standing, the students' perception of value and their anticipated interest show significant differences between students from different class standings, with a decrease as the students have higher class standing. Of interest is to note that even when not statistically significant, there is a higher perceived pressure based on class standing, particularly between third year students compared to first and fifth year students.

Table 4. Test statistics for Hypothesis 2 and 3

Variable	F	Sig.	Conclusion
Interest filtered by country (H_{2a})	2.087	0.069	Do not reject hypothesis
Interest filtered by class standing (H_{2b})	3.143	0.016	Reject hypothesis
Value filtered by country (H_{3a})	1.278	0.275	Do not reject hypothesis
Value filtered by class standing (H_{3b})	3.422	0.010	Reject hypothesis

Results indicate a high level of interest and perception of value in the multinational experience, with no significant differences due to specific geographic location but with some differences based on their class standing.

6 Conclusions

The motivation by engineering and engineering technology students to be part of collaborative multinational design projects has been studied. Evaluation of two particular constructs of motivation, interest and perceived value, is done as a function of two demographic parameters of relevance for multinational projects, geographic

location and class standing. A questionnaire based on the IMI was used as instrument for evaluation of the participants from seven academic institutions at six countries.

From the results, it can be determined that both interest and perception of value were at high level in the students responses, with some numerical differences based on geographic location and class standing. However, no statistically significant differences were observed on interest and perception of value based on location, but there was a decrease in that interest and perception of value with students with more years of college experience (higher class standing). Additional observations during the project and preliminary results of exit surveys show that the level of interest diminishes during the duration of the project. More research on this observation will follow to determine possible causes and create appropriate intervention actions to maintain a high level of motivation and, as consequence, an academic experience conducive to reach the expected learning outcomes.

The attractiveness of the experience for the students is high but the capacity to maintain a good level of motivation seems influenced by the trend assumed of the project. In particular, personal interactions between the participants assume an important role to the success of the experience. The language and cultural differences can influence the work of the cluster as well as the compulsoriness of the activity for some teams produces a different interest in the participants. Keep into account of these aspects during the preparation of the activity should permit to obtain better results concerning the motivation.

The results from this study are a useful guideline in the definition of PBL activities where multinational collaborations are planned. In current and future professional environments, it will be essential to have such guidelines in order to address the expectation being placed by the coming smart society.

References

1. Felder, R.M., Silverman, L.K.: Learning and teaching styles in engineering education. *Eng. Educ.* **78**(7), 674–681 (1998)
2. Jean, G., Simard, D.: Deductive versus inductive grammar instruction: Investigating possible relationships between gains, preferences and learning styles. *System* **41**(4), 1023–1042 (2013)
3. Ary, D., Jacobs, L.C., Sorensen, C.K., Walker, D.: *Introduction to Research in Education*. Cengage Learning, Belmont (2013)
4. Cohen, L., Manion, L., Morrison, K.: *Research Methods in Education*. Routledge, New York (2013)
5. Bransford, J., Brown, A.L., Cocking, R.R.: *How People Learn: Brain, Mind, Experience, and School*. National Academy Press, Washington (1999)
6. Krajcik, J.S., Blumenfeld, P.C.: Project-based learning. In: Sawyer, R.K (ed.) *The Cambridge Handbook of the Learning Sciences*, pp. 317–334. Cambridge University Press, Cambridge (2006)
7. EC–European Commission: *ECTS users' guide*. office for official publications of the European communities, vol. 60 (2009)

8. Barnett, R.: *The Limits of Competence – Knowledge*. Higher Education and Society. SRHE and Open University Press, Buckingham (1996)
9. Esparragoza, I.E., Lascano-Farak, S., Ocampo, J.R., Nuñez-Segovia, J., Vigano, R., Duque-Rivera, J., Rodriguez, C.A.: Assessment of students' interactions in multinational collaborative design projects. *Int. J. Eng. Educ.* **31**(5), 1255–1269 (2014)
10. Weber, K.: The relation of interest of internal and external motivation. *Commun. Res. Rep.* **20**(4), 376–383 (2003)
11. Benson, L., Kirn, A., Morkos, B.: CAREER: student motivation and learning in engineering. In: *Proceedings of the 120th ASEE Annual Conference 7 Exposition*, Atlanta, GA, 23–24 June 2013 (2013)
12. Sancho, P., Fernandez-Manjon, B.: Experience in using a MUVE for enhancing motivation in engineering education. In: *Proceedings of the IEEE EDUCON Education Engineering 2010*, Madrid, Spain, 14–16 April 2010 (2010)
13. Lopez-Fernandez, D., Alarcon, P.P., Tovar, E.: Motivation in engineering education: a framework supported by evaluation instruments and enhancement resources. In: *Proceedings 2015 IEEE Global Engineering Education Conference (EDUCON)*, Tallinn University of Technology, Tallinn, Estonia, 18–20 March 2015 (2015)
14. Chachra, D., Dillon, A., Spingola, E., Saul, B.: Self-efficacy and task orientation in first-year engineering design courses. In: *Proceedings Frontiers in Education Conference (FIE)*, Madrid, Spain, 22–25 October 2014 (2014)
15. Reeve, J.: *Motivating Others: Nurturing Inner Motivational Resources*. Allyn & Bacon, Needham Heights (1996)
16. Franken, R.E.: *Human Motivation*. Wadsworth/Thomson Learning, Belmont (2002)
17. Jones, B.: Motivating students to engage in learning: the MUSIC model of academic motivation. *Int. J. Teach. Learn. High. Educ.* **21**(2), 272–285 (2009)
18. Schunk, D.H., Pintrich, P.R., Meece, J.L.: *Motivation in Education: Theory, Research, and Applications*. Pearson, Upper Saddle River (2008)
19. Weber, K.: The relationship of interest to internal and external motivation. *Commun. Res. Rep.* **20**(4), 376–383 (2009)
20. Hidi, S., Renninger, K.A.: The four-phase model of interest development. *Educ. Psychol.* **41**(2), 111–127 (2006)
21. Alexander, P.A., Kulikowich, J.M., Jetton, T.L.: Interrater relationship of knowledge, interest and recall: assessing the model of domain learning. *J. Educ. Psychol.* **18**(4), 559–575 (1995)
22. Eccles, J., Adler, T., Futterman, R., Goff, S., Kaczala, C., Meece, J.: *Expectancies, Values, and Academic Behaviors*. W.H. Freeman, San Francisco (1983)
23. Stover, J.B., Iglesia, G., Boubeta, A.R., Liporace, M.F.: Academic Motivation Scale: adaptation and psychometric analyses for high school and college students. *Psychol. Res. Behav. Manag.* **5**, 71–83 (2012)
24. Jones, B.D., Epler, C.M., Mokri, P., Bryant, L.H., Parette, M.C.: The effects of a collaborative problem-based learning experience on students' motivation in engineering capstone courses. *Interdisc. J. Prob Based Learn.* **7**(2), 34–71 (2013)
25. Saalman, E.: Active learning – opportunities and challenges with MOOCs. In: *Proceedings of the 13th International Workshop Active Learning in Engineering – ALE*, San Sebastian, Spain, 6–9 July 2015
26. Bandura, A.: *Self-efficacy: The Exercise of Control*. W.H. Freeman and Company, New York (1997)
27. Esparragoza, I.E., Ivashyn, U.: Developing a learning module to enhance motivation and self-efficacy of students participating in multinational design projects. In: *Proceedings of the 123rd ASEE Annual Conference and Exhibition*, New Orleans (2016)

28. Rodriguez, J., Simavilla, A.L., Cura, J.M., Ezquerro, J.M., Lapuerta, L., Gracia, M.C.: Project based learning experiences in the space engineering education at technical university of Madrid. *Adv. Space Res.* **56**, 1319–1330 (2015)
29. Bender, W.N.: *Project-Based Learning: Differentiating Instruction for the 21st Century*. Corwin, Thousand Oaks (2012)
30. Lam, S., Cheng, R.W., Choy, H.C.: School support and teacher motivation to implement project-based learning. *Learn. Instr.* **20**, 487–497 (2010)
31. Morales, T.M., Bang, E.J., Andre, T.: A one-year case study: understanding the rich potential of project-based learning in a virtual reality class for high school students. *J. Sci. Educ. Technol.* **22**, 791–806 (2013)
32. Heo, H., Lim, K.Y., Kim, Y.: Exploratory study on the patterns of online interaction and knowledge co-construction in project-based learning. *Comput. Educ.* **55**, 1383–1392 (2010)
33. Neto, O.M.; Lima, R.M.; Mesquita, D.: Project-based learning approach for engineering curriculum design: faculty perceptions of an engineering school. In: *Proceedings of Project Approaches in Engineering Education*, pp. 112–119 (2015)
34. Pouzada, A.S.: *Project Based Learning*. UMinho, Guimarães (1999)
35. Stock, J., Cervone, D.: Proximal goal-setting and self-regulatory processes. *Cogn. Ther. Res.* **14**(5), 483–498 (1990)
36. Ponton, M.K., Edmister, J.H., Ukeiley, L.S., Seiner, J.M.: Understanding the role of self-efficacy in engineering education. *J. Eng. Educ.* **90**(2), 247–251 (2001)
37. Johnson, R.A., Wichern, D.W.: *Applied Multivariate Statistical Analysis*, 5th edn. Prentice Hall, Upper Saddle River (2002)
38. Törlind, P.: Collaborative design. *J. Indian Inst. Sci.* **95**(4), 353–364 (2016)
39. DeVoss, D., Jasken, J., Hayden, D.: Teaching intracultural and intercultural communication. A critique and suggested method. *J. Bus. Tech. Commun.* **16**, 69–94 (2002)
40. Esparragoza, I., Ocampo, J., Rodriguez, J., Lascano, S., Ivashyn, U., Sacchelli, C., Vigano, R., Duque, J.: Engineering students motivation on multinational projects: a comparison based on interest, value and gender. In: *Proceedings of the 14th International Latin American and Caribbean Conference for Engineering and Technology, LACCEI 2016*, San Jose, Costa Rica, 20–22 July 2016 (2016)
41. Monteiro, V., Mata, L., Peixoto, F.: Intrinsic motivation inventory: psychometric properties in the context of first language and mathematics learning. *Psicol. Reflex. Crit.* **28**(3), 434–443 (2015)
42. Deci, E.L., Ryan, R.M.: The “what” and “why” of goal pursuits: human needs and self-determination of behavior. *Psychol. Inquiry* **11**(4), 227–268 (2000)
43. Pinjala, S., Pintelon, L., Vereecke, A.: An empirical investigation on the relationship between business and maintenance strategies. *Int. J. Prod. Econ.* **104**, 214–229 (2006)
44. Terron-Lopez, M.-J., Velasco-Quintana, P.-J., Garcia-Garcia, M.-J., Ocampo, J.R.: Students’ and teachers’ perceptions: initial achievements of a Project-Based Engineering School. *Eur. J. Eng. Educ.* pp. 1–14 (2016)
45. National Science Foundation, Division of Science Resources Statistics: Women, minorities, and persons with disabilities in science and engineering: 2011. Special report NSF 11-309, Arlington, VA (2011). <http://www.nsf.gov/statistics/wmpdf/>



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