INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Aligning Engineering Education with Engineering Challenges



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The Importance of the Project Theme in Project-Based Learning: a Study of Student and Teacher Perceptions

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Abstract

Motivation to Learn represents a prime driving force in Engineering Education. It encompasses a multitude of facets relating the learning process itself and the learning agents, namely students and teachers. Motivation is triggered both by learning agents inner strengths, level of interaction and particular perception of the learning objects relevance. This paper investigates the relevance of the project themes within the context of interdisciplinary project-led engineering education at University of Minho, Portugal. The study is backed-up by results from the 2010-2011 PLE edition of the Integrated Master degree on Industrial Management and Engineering. This includes results from a questionnaire applied to students, a questionnaire applied to the group of teachers. Analysis of results show a strong link between students and teachers perceptions on theme relevance, while giving insights into aspects that should be taken into account when analysing and making a decision on semester-wide project themes.

Keywords: project based learning; active learning; motivation; project theme.

1 Introduction

This paper studies the relevance of the theme of interdisciplinary projects, in the context of active learning methods in engineering education, namely in Project-Led Engineering Education (PLE). The study is based on the interdisciplinary project of the first year of the Integrated Master´s degree in Industrial Management and Engineering (IME) at the University of Minho (Portugal). The case study (IME1.1) enabled data collection on motivational aspects of the theme of the project, through questionnaires to students and teachers, complemented by a workshop held at the end of the semester. The paper seeks to present the results of the data collection, followed by a critical analysis and validation of the results, as well as to present conclusions on the results.

The PLE methods has been implemented in a number of Institutions of Higher Education in Europe as well as North-America and Australia (Powell & Weenk, 2003). The University of Twente, the Netherlands, adopted the method in 1994 (Ponsen & Ruijter, 2002) aiming to prepare engineers for the labour market, with solid technical background along with team working practice and experience in tackling and solving multidisciplinary problems, apart from a high level of performance, autonomy and communication skills (Powell & Weenk, 2003; Helle et al., 2006).

One of the main goals of the PLE methodology is the increase of students motivation in the development of technical competencies (embodied in the courses that support the interdisciplinary project) and for the development of transferable competencies (like project management, conflict management, oral and written communication, self-regulation of learning, etc.). It is supposed that the project theme plays a crucial role in stimulating the interest and motivation of the students, allowing at the same time for interdisciplinarity in the approach, and as such providing an intrinsic interest in the technical competencies of the related courses.

Powel and Weenk (2003) describe the characteristics that a good project should have and distinguish academic issues (e.g. compliance with course goals, offering multidisciplinary open-ended tasks, enabling integration of knowledge, attitudes and values), reality issues (e.g. relevance for students, connections with real life and connections with business), student issues (e.g. requiring a team challenge, requiring individual responsibility, allows teams to reach distinctive solutions) and the end product (e.g. a working prototype, drawings, an invention or a written report).

The theme of the project is the actual starting point of the project semester. According to a study of Gommer and Rijkeboer (2010) with the teaching staff at the University of Twente using a PLE approach, there are various strategies to catch and maintain the interest of motivated students, to carry out the project till its very

end. They refer that projects should be fun (Gommer and Rijkeboer, 2010, pp. 102) and they explain the fun-factor as follows.

- Connect with the interests and environmental perceptions of the target group. For example, projects in the first year of the mechanical engineering programme are perceived as 'fun' when students are asked to design a so called 'demolishing device' (e.g. a can crusher).
- The value of the solution to be designed has to be clear to students. An example of a less successful project is designing a shoe polishing machine. This is something that can be easily done by hand. Students didn't see the use for a machine to solve this problem.
- Connect with actuality or a so called 'hot item'. Sustainability for example is a theme that is perceived as relevant by industrial design engineering students.
- Manufacturability. Especially for students in the first year of the programme, it's motivating to design a solution that can be made into a working full-scale prototype. Often, a fun closing session is organized, in which a contest is held with the working prototypes (battle robots, baking sausages on barbeque designs, etcetera).

The same study also highlights that for the teaching staff, the so-called fun-factor is important. The project assignment, when carrying out projects year after year, needs to be original and appealing to them in order to keep them engaged (Gommer and Rijkeboer, 2010, pp. 102). Moreira and Sousa (2008) describe the use of prototypes of production systems in interdisciplinary IME projects. Their study reports on the increased enthusiasm, autonomy in the development of prototypes as well as the cooperation and competition between contending teams and seem to confirm some of the results recorded by Gommer and Rijkeboer (2010).

2 Project Theme and Motivation

According to features of PLE, the importance of interdisciplinarity is in the definition, development and evaluation of the project. The interdisciplinarity is an important dimension to take into account in the planning of the project, particularly in the definition of the theme, in order to assure the demands of the different curricular units. The integration of the contents is one of the most complex and challenging dimensions in this methodology. However, some barriers to interdisciplinarity are discussed in literature: (1) differences in the characteristics of disciplinary knowledge; (2) differences in disciplinary traditions to teaching and learning; (3) different approaches to student learning; and (4) different conceptions of teaching and learning (Bradbeer, 1999).

The project theme in PLE is expected to be based on the professional context in order to provide learning situations to students, where they can apply knowledge to solve engineering problems and they can also develop competencies related with the engineering practice (Pesches & Reindel, 1998; Moesby, 2005; Nair et al. 2009). In the definition of project theme there is a concern of the teachers to choose one that may keep students' motivated during the semester. At same time, the theme should be a motivator for teachers in order to encourage students, to ensure the quality of the process and to bring innovation with great enthusiasm in teaching practice (Lam et al., 2008).

Motivation is a central issue in the life-cycle of the project, so is an important dimension for the learning process and for the relation between students and teachers. Hill (2007) mentions the factors that affect students' motivation to learn: contextualization learning in the students' world, bringing real-world issues into the learning contexts, giving students choice, autonomy and self-regulation over their learning, and providing feedback. Schunk (1999) developed this idea establishing the relation between two variables: expectations, which involve the capabilities for learning (self-efficacy) and perceptions of the consequences of learning; and value which is related to perceiving the importance of learning. In this order, motivation drives behaviour and in the project students are oriented through objectives that they must achieve not only at the end (learning outcomes) but also during the process. For that reason, the project theme is crucial for the students' and teachers' motivation, because it has an impact on learning and teaching process. Additionally, it is the theme that allows an interdisciplinary approach in the project, relating competencies that students are to develop in each individual course to achieve the objectives of the project.

3 Methodology

In order to collect data on the perceptions of students regarding their participation on the 2010/2011 edition of the first year first semester IME project, a questionnaire (*Questionnaire* A_1) was developed and applied. A

second questionnaire (*Questionnaire A_2*) was developed and applied to teachers, tutors and educational researchers, involved in the same project.

Questionnaire A_1 was intended to extensively collect students' perceptions on the full project experience. It consisted of 46 closed items and two open items. The closed items were divided into six scales having between six and ten items each. The first scale focused directly on the project theme of the semester: Air_2Water - specification of a portable device for the production of drinking water from air humidity and the specification of its respective production system. It contained six questions related to e.g. the relevance of the theme and the motivation for the theme. The remaining scales were focused in several other aspects which are out of scope of the present study. These were targeted at learning and competencies developed, teamwork, role of the tutor and of teachers involved, project assessment methodology, and contribution of project-led education methodology to the learning process. The open questions referred to positive and negative aspects of the project experience, as well as suggestions for improvement.

Questionnaire A_2, for teachers, tutors and educational researchers, was aimed specifically at project themes, not only of the last project, but of all projects that have been run. The questionnaire had five scales, of which the last two were exclusively directed at teachers. The first scale, with six items, aimed specifically the present PLE edition theme, i.e. Air_2Water project. The second scale asked the respondents to rank all eight project themes of projects that have taken place between 2004/2005 and 2010/2011 from 1 to 8, the former being the most important one. The respondents needed to justify their ranking. The following question required the respondents to identify what aspects of a project theme they considered most important, e.g. social relevance, innovation, economical potential. The last two questions asked teachers to reflect on the choice of this year´s project theme and the initial expectations with regard to the theme in comparison with the results of the project.

The sample for A_1 was a group of 24 students out of a population of 42, meaning 57% of the total population. The sample for A_2 73%, 11 out of a population of 15. The questionnaires were both applied at the end of the first semester of the academic year 2010/2011.

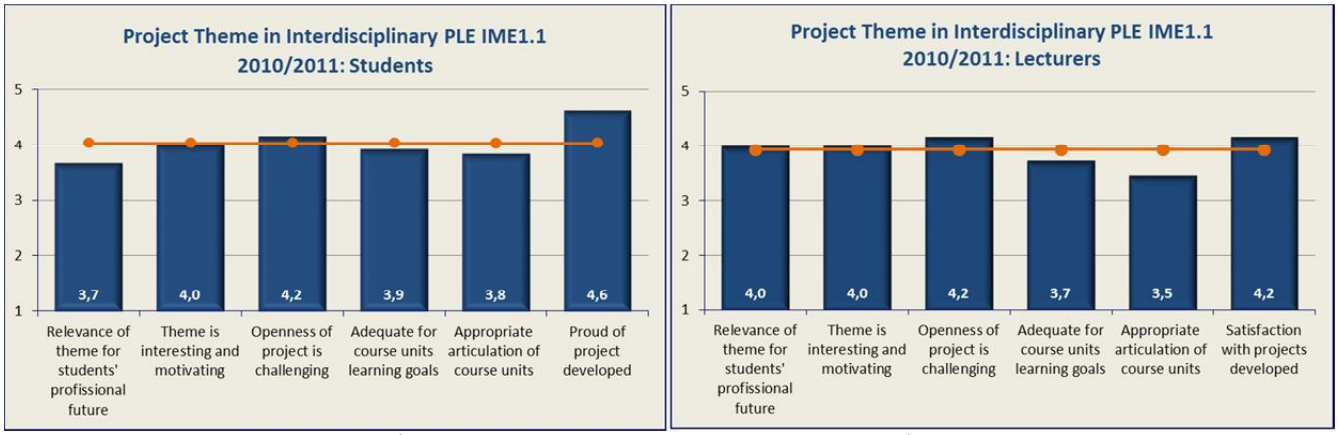
4 Findings

A good rate of responses was attained to both Questionnaires A_1 and A_2. Three of the teachers (pertaining the teachers/tutors group) were simultaneously tutors of student teams and lecturers of a course unit. In this way, among teaching staff, only one of the teachers of the courses involved and one of the tutors did not respond to the questionnaire. For simplicity of reading respondents to Questionnaires A_2 (tutors only; teachers/tutors; teachers only; and educational researchers) will be referred as lecturers. The detailed figures for respondents are exhibited in Table 1.

Table 6: Milestones

Respondents	Population	Sample	Percentage
Questionnaire A1			
Students	42	24	57%
Questionnaire A2			
Tutors only	3	2	67%
Teachers/Tutors	3	3	100%
Teachers only	5	4	75%
Educational Researchers	4	2	50%

The average results of each item pertaining scale 1, which relates to Project Theme Relevance, are depicted in figure 1. Figure 1a) show results to *Questionnaire A_1 (students)* and Figure 1b) show results to *Questionnaire A_2 (lecturers)*. Overall results indicate a very similar pattern of perceptions between students and lecturers regarding all six closed items. A more detailed analysis of the results follows.



a) b)

Fig. 1 Project Theme relevance (section 1). a) Results to *Questionnaire* A_1; b) Results to *Questionnaire* A_2

The similarities between students and lecturers perceptions are evident, according to results on all items of scale 1. The mean score on scale 1 is 4.0 for students and 3.9 for lecturers. The scores on this first scale indicate an overall positive opinion with regard to the project theme.

The strongest agreement between results of questionnaire A_1 and A_2 is to be found in item 2 – *Project theme is interesting and motivating for students;* and item 3 – *Openness of project is challenging* - (scores of 4.0 and 4.2 respectively). The clearest discrepancy between students and lecturers (0.4 points) is found on item 6 – *Proud/satisfaction for the project developed by the students*. But, such deviation is not attributed to low satisfaction levels by lecturers (averaged 4.2, which is a good mark overall) with the projects developed by students' teams. Rather, it is essentially attributed to an abnormally high students pride with the projects that teams have developed along the semester (having a 4.6 mean score).

The item that showed most concern for lecturers (lowest mean score of all items of the section) is related to the success of articulation between the different subjects involved in the semester (item 5 – *Appropriate articulation of course units*). The mean score was 3.5. It is less worrying for the students as their mean score was 3.8.

The item that showed most concern for the students refers to the relevance of the project theme and how that is related to their professional future (item 1), being characterised by 3.7 mean score. Results to item 1 on Questionnaire A_2 (lecturers) does not indicate equivalent concern (mean score of 4.0).

Item 4 – *Adequate for course units learning goals*, has been scored with 3.9 by students and 3.7 by lecturers.

Section 2 of the lecturers' questionnaire (A_2) sought to identify the perceptions with regard to the project themes of all interdisciplinary projects that have taken place between 2004 and 2011 in eight editions of the perfect. Table 2 ranks all these projects.

Table 2: Rank of relevance of themes of IME interdisciplinary projects (lecturers' perceptions).

Rank	Project theme	PLE IME1.1 Edition
1st	Production system of biodiesel	2004/2005
2nd	Specification of a system for the transformation of forest biomass	2005/2006
3rd	Production of batteries for an electric car; specification of the battery and its production system	2008/2009
4th	Specification of a production system for fuel cells	2006/2007 S_1
5th	Use of organic waste for the production of bio-alcohol	2009/2010
6th	Desalinisation of sea water	2007/2008
7th	Air_2Water – Specification of a portable device for the production of drinking water from air humidity and the specification of its respective production system	2010/2011
8th	Space Tourism	2006/2007 S_2

As table 2 shows, the theme of the very first edition of the project, a production system for the production of biodiesel, was regarded as the most relevant one. The least motivating one took place in the second semester of 2006/2007 and was aimed at Space Tourism; this rank was unanimous among lecturers.

The theme of the most recent project was considered the penultimate one in terms of relevance, which is surprising considering the positive scores to 2010/2011 project theme, given by students and lecturers, expressed in the results shown in figure 1a) and 1b). The comments that the teachers gave on the open items indicate reasons to explain the importance of a theme:

- Appropriateness for the course involved
- Possibility to apply contents of courses involved
- Appropriateness of the theme
- Relevance for the IME professional profile
- Theme close to actual reality
- Realistic theme
- Level of complexity adequate for 1st year students
- Theme that is well embedded in the thematic technology of a specific edition
- Theme with a strong environmental focus, sustainability and economic potential
- Theme that relates well to the different subjects involved
- Perception (at the end of the project) that the students liked the project and achieved the learning goals
- Theme that provides an easier view on the productive process
- Motivating challenge
- Theme that offers an urgent problem (pointing at the "perfect" solution/application)

With regard to the less important themes, the following reasons were indicated in the open question:

- Theme is not interesting for the students
- Theme is not important
- The relevance for the professional future is low
- The perception that students considered the theme as little relevant and distant from the professional competencies in Industrial Engineering.

In section 3 of questionnaire A_2, the teachers had to identify the three most relevant aspects concerning the choice of the project theme for first year first semester project (1 – most important, 3 – least important).

- *Theme well embedded in currently relevant issues*
- *Innovating theme*
- *Theme with clear links to the competencies to be developed in the related courses*
- *Theme with high economic potential*
- *Theme with high social relevance*
- *Theme focused on environmental or energy questions*
- *Theme related to the professional profile of a Industrial Management and Engineering graduate*
- *Other, please explain.*

The aspect that was considered most important was *Themes related to the professional profile of a Industrial Management and Engineering graduate,* followed directly by *Theme with clear links to the competencies to be developed in the related courses*. The theme being related to current issues and the energy/environment link were also considered important aspects. The remaining aspects were considered less important for the definition of a project theme.

The fourth section of the teachers' questionnaire was exclusively aimed at the teachers who were responsible for the courses involved in the project. As indicated above, seven out of eight teachers responded to this section. The first question referred to the level of satisfaction with the project theme taking into account the appropriateness of the project theme for the learning outcomes of the course that the teacher is responsible for. Out of seven, four were satisfied and three were very satisfied with the appropriateness of the theme. The first four teachers made the following comments:

> *"The students could choose, within certain conditions, what they wanted to do. And it was possible to apply part of the content in the construction of the artefact" (the production of water from air humidity)*
>
> *"The project allowed for the application of concepts of discrete production, part of the learning outcomes of the course"*
>
> *"It is never a 100% as there will always be contents that are not covered by the project"*

The three teachers who were very satisfied commented:

> *"I believe that the established goals were achieved, explaining my satisfaction"*

"The theme allowed for the achievement of the Industrial Management and Engineering learning outcomes"

"Very happy with the choice – great application potential. Little satisfaction with the concretization as the students were not able to put the solution into practice (I had high expectations)"

The second question in section 4 was related to the level of satisfaction of the initial expectation compared to the development of the project in the first semester of the first year by the students of the academic year 2010-2011. Six out of seven teachers said to be *satisfied* and one was *very satisfied* with regard to the comparison between initial expectation and the development of the project. Some of the first six commented:

"In the beginning I was not very happy as I could not envision the development of a production system, but later on I saw that the project was adequate."

"The groups developed the device and the production systems, meeting the standards for a first year first semester course of a five year degree programme."

"In general, I think that the groups did a good Job. In order to classify for "very satisfied", the projects had to be more different"

The teacher that was *very satisfied* with the projects, was surprised that final results matched initial expectations.

5 Conclusions

The data obtained in this study are on both student and teacher opinions on the impact of a project theme. Due to the research design of the study, the student opinions only refer to the last edition of the project and the opinions of teachers refer to all past editions as well. In spite of this incongruence in the data, some conclusions on the choice of a project theme and the factors that should be taken into consideration can be drawn.

Firstly we can conclude that both teachers as well as students find that a specific project theme has an impact on their motivation for the project. With regard to the most recent project, the opinions of students and teachers largely coincide, as both find the openness of the project and the challenge it offers a crucial factor for the success of a project, as well as the final result that can be achieved through the project. The way the theme articulates the connections between the courses involved in the project seems to be a first worry for lecturers, but of less importance for students. Looking back to previous projects, the teachers highly agree on what were the most and the least interesting project themes. The very first project theme on biodiesel was considered the most appropriate theme and the theme on space tourism was unanimously referred to as the least interesting one. Looking at the comments that teachers gave, the latter is not difficult to explain. The most relevant aspect for the choice of a theme is, according to the teachers, the relationship with the professional reality of an Industrial Management and Engineering graduate and the space tourism theme was the least realistic theme. It offered a large challenge to the students and was contextualised by existing space tourism initiative, but in the end the students found the theme rather artificial and not properly preparing them for their future work. The biodiesel, as well as the themes that ranked second and third, were directly related to current energy and environmental concerns.

The results of the study indicate that the initial stage of the project, in which the project theme is defined, should carefully take into account all aspects that can influence motivation and especially link to students' future professional reality. A focus on sustainability, energy and the environment is also important to take into account.

Furthermore, the results learn that a longitudinal study on both the teacher and the student perspective on the impact of the project theme will provide more balanced results that enable for a more insight into how project theme influences the learning outcomes and perception of the project results.

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