Five Years of Project-Based Learning Training Experiences in Higher Education Institutions in Brazil

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Abstract

Implementing Project Based Learning (PBL) is a challenging enterprise both for students and for teachers. PBL demands a changing process in which teaching is about being able to work with other teachers in an environment open to uncertainty, with creativity, improved communication and engagement. Considering the need to support teachers to implement PBL, a group of researchers delivered 19 workshops since 2010 in 16 Higher Education Institutions in Brazil. These workshops were delivered using a PBL approach and most of them had 20 hours of training. This study aims identifying the impact of these workshops and discuss the contribution of staff development strategies to improve engineering teaching practice. The methodological approach carried out for this study was based on an online questionnaire exploring the participants' perceptions about their experience in the workshop and the impact on their teaching practice using active learning strategies (difficulties, motivations, etc.). The questionnaire was sent to 367 participants' active email addresses. The findings, from the 67 answers received, point out that 95% of respondents said that the workshops have had an impact on their teaching practice, and in general, they are applying what they have learned in the workshops. The participants' motivation came from the interest in learning new teaching strategies, sharing experiences, improving student learning, innovating and even just out of curiosity. Concerning to teachers' training, more than 75% of the respondents' claimed they have felt the need of pedagogical training at the beginning of their career, and more than 70% stated that they keep on participating in events to improve their professional practice as engineering teachers. It is important to point out all respondents consider important or very important the existence of a professional teachers' development program in their institutions, and the pedagogical training was highlighted as the most needed, followed by the formation of practice communities and research groups. Based on the participants perceptions it was possible to present a short list of general recommendations for the development of engineering teachers training opportunities.

Keywords: Project-Based Learning; Active Learning; Staff Development; Engineering Education

Type of contribution: Research paper

1 Introduction

Active learning strategies are associated with meaningful contextual experiences, where the student is in the centre and actively engage in the learning process, being able and having the opportunity to reflect upon what they are learning (Bonwell & Eison, 1991; Felder & Brent, 2003; Prince, 2004; Prince & Felder, 2006). Although learning could be seen as a synonym of active learning (Christie & de Graaff, 2017), there is a set of innovative student centred methods (Lima, Andersson, & Saalman, 2017) that potentiate students' success

(Freeman et al., 2014). Among active learning strategies in engineering education, Problem and Project-Based Learning are some of the most common approaches refereed in journal articles (Lima et al., 2017).

Engineers are professionals that design solutions to solve society problems through the execution of projects. Considering this perspective of the engineering profile, it is expectable that active learning approaches for engineering education are strongly related to Problem and Project-Based Learning (PBL). In such approach, teams of students cooperate for solving open-ended problems linked to the professional activity (Edström & Kolmos, 2014; Graaff & Kolmos, 2003; Powell, 2004; Powell & Weenk, 2003).

All around the world, higher education (HE) teachers are not prepared to become teachers. Usually, having a PhD in a specific technical knowledge area is enough to become a teacher in that area. Even though in some countries during their postgraduate studies they do some classes related to pedagogical issues (Cargnin-Stieler, Teixeira, Lima, Mesquita, & Assunção, 2016), their preparation is low or inexistent in relation to what (Zabalza, 2009) defines as fundamental processes to improve teaching quality: methods, content selection, learning environments, student support learning support materials, teachers' coordination and evaluation. Therefore, training higher education teachers will provide them with competences that can improve the quality of the teaching and learning processes, namely communication, teamwork and planning (Sadler, 2012; Tigelaar, Dolmans, Wolfhagen, & van der Vleuten, 2004; Zabalza, 2009).

Considering that most of the current higher education teachers did not have active learning strategies during their undergraduate and graduate training, they do not have experience with these approaches, not even as learners. Thus, supporting teachers for implementing active learning strategies is a need for changing the teaching and learning processes. This need created a demand for cooperating with several institutions and since 2010, a set of 19 teacher training workshops in PBL were delivered in 16 Brazilian higher education institutions. These workshops were delivered using a PBL approach and most of them had 20 hours of training. With this study the authors aim to identify the impact of these workshops and discuss the contribution of professional development to improve engineering teaching practice.

2 Research Background

L. R. Fernandes and Silva e Filho (2015) say that industry in Brazil expects engineers with personal abilities that transcend the reasoning skills, traditional on STEM graduate courses, and one important suggestion they present in their work is the incentive of innovation projects. Thus, it is important to include some active learning strategies within the engineering curriculum (Loder, Nakao, & Filho, 2014; Mesquita, Flores, & Lima, 2015; Mesquita, Lima, Flores, Marinho-Araujo, & Rabelo, 2015). These strategies could be very positive because with more engaged and motivated students, it is supposed to have less dropouts and students tend to be engaged in their own learning process (S. Fernandes, Mesquita, Flores, & Lima, 2014).

In addition, to satisfy the labour market expectations, engineering schools in Brazil need to be more attractive to students. According to Engenharia Data Annual Report (Salerno & Lins, 2015), although engineering is still one of the most attracting areas, a reduction in the number of freshmen was observed in 2013 and the dropout rate was about 22%. Dropouts are a waste of educational resources and a waste of student's resources (Kolari & Savander-Ranne, 2002). This report, organized by Salerno and Lins (2015), also remind us that Brazil forms only 2.93 engineers per 10.000 habitants, while Finland makes 34.02 and Portugal, for example, 25.40. The data cited above indicates the need for a change in engineering education in Brazil. It is important to point out that this improvement is not only about curriculum development and technological improvements, being also essential to develop studies about engineering education changes, and research

engineering teachers' training programs to support all the required changes (Mesquita, Lima, et al., 2015; Villas-Boas, Booth, Mesquita, & Lima, 2016).

Teaching is a complex activity and both teachers and institutions need to be aware of this fact, it requires multiple knowledges that need to be carefully prepared and understood in their relationships. Besides, the teaching-related issues are behind cognitive barriers, such as methodologies, terms, among others. The university pedagogy is a space of connection of knowledge and cultures (Cunha, 2009). University professors do not have training focused on the teaching-learning processes, for which they are responsible in their academic life (Almeida, 2012; Gaeta & Masetto, 2013).

In the context of higher education, active learning involve students in the development of activities and make them think about what they are doing. Students get involved and engaged in the proposed activities, feeling motivated while developing analytical, synthesis and evaluation skills (Bonwell & Eison, 1991). Students learning process using active learning techniques is more efficient, because the student are engaged in activities that are similar to real situations, many of which are situations that an expert engineer faces daily at work (Freeman et al., 2014).

The advantage of this approach is that students learn how to interact with each other and the community around them, developing competences related to their professional contexts, acquiring knowledge, and developing attitudes and behaviours that enable them to better deal with real scenarios after finishing their studies. Project Based Learning facilitate students to experience the relationship between science and the reality of the labour market, and enhance interdisciplinarity (Graaff & Kolmos, 2003; Lima, Dinis-Carvalho, Flores, & Hattum-Janssen, 2007; Powell, 2004; Powell & Weenk, 2003).

On the same line of thought, Dahms (2014) argues that

"(…) the learning process in a PBL environment takes its point of departure in an ill-structured real-life problem – and this approach has a very strong motivational impact on students' learning processes. One of the recognized strengths of PBL is that, apart from professional engineering competences, students also develop methodological competences in areas such as project management, teamwork, negotiation, communication, problem solving".

The shift from a traditional teaching environment, usually teacher centred, to an active learning PBL environment, which is student centred, requires the transformation of several elements in the institution. It is necessary to make modifications in several areas of the curriculum and teachers training is a value starting point (Schneider & Preckel, 2017). Understanding how PBL is works is an essential phase for all students and teachers. The role of the teacher must be modified, and he or she must be able to deal with learning processes with less control of the situation; they should know how to help student's to develop transversal competences, for example. Teachers must be able to create and lead active learning environments that will contribute to the formation of more creative engineers with the profile expected by the labour market (Lima, Mesquita, & Flores, 2014; Mesquita et al., 2016; van Hattum-Janssen & Mesquita, 2011).

3 Context of the Study

The first four workshops were delivered from September to December 2010, starting with the need to support the Industrial Engineering and Management program at the University of Brasília, Brazil. This program was created one year before with Project-Based Learning (PBL) principles but there was no specific implementation plans at that point and teachers had a lack of previous experience and training on PBL.

Table 1 presents a summary of the workshops delivered since 2010. The 19 workshops were delivered by Trainer A. All of the workshops are planned to be delivered by two trainers, and only if this is not possible, one trainer will deliver the workshop. Only two of those workshops were delivered just by one trainer (A). Fifteen workshops were delivered by Trainer A and B and two workshops were delivered by Trainer A and C. Trainer A has background of Engineering and Trainers B and C have background from education sciences. The three trainers have research experience with PBL education environments. The participants were mainly volunteers and the registration in the workshops was managed by the institutions.

Regarding the workshop themes, the great majority of the workshops were adapted to the institution needs centred on Project-Based Learning implementation. These workshops are planned for teams of participants to deliver a PBL plan at the end. The project that is asked from the participants, should be based on an interdisciplinary project that will join several courses and its teachers and students. In 20 hours workshops, this plan should include the project theme, project phases, curriculum alignment, learning outcomes of the project, assessment model, and results that students should be able to deliver. The 8 and 12 hours workshops are intended to make an introduction to PBL implementation, and the result will be based on a poster illustrating the project implementation proposal. In shorter workshops it will not be possible to explore the assessment model and the curriculum alignment issues.

Table 1. Summary of workshops

Institution	Local	Workshop	Duration	Date1	Date2	Trainers
UnB	Brasília	PBL	20H	2010.10.05	2010.10.11	Trainer A; Trainer C
UNESP	Bauru	PBL	20H	2010.11.16	2010.11.18	Trainer A; Trainer B
UnB	Brasília	PBL	20H	2010.11.21	2010.11.28	Trainer A; Trainer B
PUC-SP	São Paulo	PBL	20H	2010.11.29	2010.12.02	Trainer A; Trainer B
UnB	Brasília	PBL	20H	2011.06.28	2011.06.30	Trainer A; Trainer B
USP-SC	São Carlos	PBL	12H	2010.10.10	2010.10.11	Trainer A
UCS	Caxias do Sul	PBL	20H	2012.02.27	2012.03.02	Trainer A; Trainer B
IDAAM e UNINORTE	Manaus	PBL	20H	2012.03.09	2012.03.11	Trainer A; Trainer B
UFJF	Juiz de Fora	PBL	20H	2012.07.31	2012.08.02	Trainer A; Trainer C
UCS	Caxias do Sul	PBL research	20H	2012.08.14	2012.08.17	Trainer A; Trainer B
UNINORTE	Manaus	PBL	8H	2013.03.08	2013.03.08	Trainer A; Trainer B
UFRN	Natal	PBL	20H	2013.03.12	2013.03.15	Trainer A; Trainer B
USP	Lorena	PBL	20H	2013.08.05	2013.08.09	Trainer A; Trainer B
MAUÁ	São Paulo	PBL	8H	2013.08.23	2013.08.23	Trainer A; Trainer B
UNISAL	Lorena	PBL	8H	2013.08.30	2013.08.30	Trainer A; Trainer B
FATEC	Guaratinguetá	PBL	20H	2014.01.29	2014.01.31	Trainer A
IDAAM	Manaus	LO	12H	2014.10.24	2014.10.25	Trainer A; Trainer B
UFRPE	Recife	PBL	20H	2015.05.11	2015.05.14	Trainer A; Trainer B
UFPA	Belém	PBL	20H	2015.05.18	2015.05.22	Trainer A; Trainer B

In summary, these Workshops are organized as an active, cooperative, participative and participant-centered teaching-learning process, which include pedagogical, project design and management issues. Management of change was discussed but was not the central aspect of the workshops. The workshop sessions are designed with an inductive enquiry approach, using Problem and Project-Based Learning, and some active learning methods (e.g. think-pair-share). The main approach throughout the workshop is based on project teamwork activities for the development of the project proposal. These activities allows to simulate an environment that teachers can replicate in their own practice.

In this model it is intended that the participants acquire competences to design, plan and control the development of students' projects. In order to develop these competences, they will have to grasp the

essential concepts of project-based learning and reflect on the advantages and constraints of building a workable plan for a project as a team. It is intended, therefore, that the training results in a plan for implementing a student project in a specific semester of a program.

4 Methodology

This study aims to identify the impact of the PBL workshops carried out in Brazil between 2010 and 2015 and discuss the contribution of staff development strategies to improve engineering teaching practice. This is a qualitative study aiming to make a description and interpretation of the type of impact those workshops had, and the perceptions these participants have about professional development. This study was oriented by two research questions:

- What is the impact for teaching practice of PBL workshops carried out in Brazil in several higher education institutions during 2010-2015?

- What are the perceptions of the teachers enrolled in the referred workshops regarding professional development?

This study was based on a survey mainly with open questions. The survey starts with an introduction and ethical considerations, presenting the context, objectives and ethics of the study. After this introduction the participants find three sections:

- Section *Participant profile*. This section collect information about participants' gender and age, professional experience, area of knowledge and level of academic education.
- Section *Workshop*. Gathering the participants' motivation for participating in the workshops and other professional development opportunities. Additionally, the survey collect information about the impact of the workshop.
- Section *Professional development training*. This section aims to understand if the participant has other experiences of professional development training, and what type of training modes could be more appealing and more effective in the participants' opinion.

The survey was developed with Google forms and a link was sent by email to 369 unique email addresses of participants of the workshops. From this 369, it was only possible to reach 338 participants, because other addresses were not valid. The number of respondents was 67, which means that this survey got a 19.8% answer rate. This answer rate allow a confidence level of 90% with a margin of error of 10%.

Less than half of the respondents (42%) were female, with ages from all respondents ranging from less than 30 years (one) to more than 60 (9 respondents). It is worthwhile noticing that more than 80% of the participants work full time period as higher education teachers. Table 2 presents the number of years of experience as a higher education teacher.

Table 2. Number of years of experience as a teacher

Years of experience	Frequency	Percentage
<5 years	8	11.9%
5 to 10 years	14	20.9%
10 to 20 years	17	25.4%
>20 years	26	38.8%
I am not a teacher	2	3%

The participants are mainly from the Engineering, Science and Technology fields, except 14 of them that are from fields of social sciences, like education, management, marketing or law. Two of these fourteen are responsible for pedagogical support in the higher education institutions that organized the PBL workshops.

5 Findings

The findings were organized in two sections. The first one is related to participants' perceptions about the workshop carried out (motivation and impact). The second section is related to participants' opinions about teachers' professional development (pedagogical training relevance and activities). Based on the findings presented some recommendations for engineering education will be also discussed.

5.1 Perceptions about the *Workshop*

Most of the participants argued that the main motivation to attend to the PBL workshop was the opportunity to develop competences related to teacher practice: How to prepare learning environments that can be interesting and attractive for engineering students? How to support students for the development of competences aligned with the engineering practice? How to create meaningful experiences for students in terms of their engagement for learning? The focus on student is the main motivation for the teachers who need to deal with the demands and complexities of teaching and learning process in engineering, particularly in the first years (e.g. student dropout and lack of students' motivation). In order words, changing the ways of teaching is changing the ways of learning. For that reason, the participants' motivation for the PBL workshop is to improve and innovate their teaching practice, learning how to do different and how to be different, as stated by this participant:

"Willing to learn and how to be a different teacher, in order to get better results in engineering education".

The participants also mentioned other kind of motivations to attend the PBL workshop: curiosity about the theme, exchange of experiences and development of knowledge in this area.

Considering the approach used in the workshop (active, cooperative, participative and participant-centred), one of the key questions is the impact of this experience on teaching practice. For 95.5% the workshop had impact at different levels, as showed in the following examples. Two researchers made the analysis of one open question related to the impact of the workshop, creating after the first reading, a set of classes that were used to collect the main evidences that are presented here.

- Changing the practice in the classroom:
  "I modified some dynamics in class, improving the relation of the student with the content of the discipline."

  "Establishment of discussion groups of practical problems in the classroom."

  "It helped me to motivate the student to work and build his/her own knowledge on some subjects."

  "I tried to pass the concepts to the students by presenting 'mini cases' and / or real problems to solve."

  "After the workshop, every semester (my classes) were planned and executed with topics that were of interest to the students and that had meaning for them. In team activities, I began to propose the students to solve their daily problems, related either with professional activities or research. I called other teachers, from sequential disciplines to mine, to join me to propose problems to be solved, so that the theme could be deepened. More integration workshops and challenges were planned and implemented. The assessment of student performance start do be done during the construction of knowledge and not at the end of something."

- Changing and reviewing curriculum approaches:
  "The workshop had a lot of impact on my teaching career. With what was absorbed, I and a group of teachers created two fully integrative and industry-oriented electives that work only with active methodologies. In all my courses I incorporated the use of active methodologies."

  "... helped clarify about the PBL and raise awareness among colleagues, and today we are proposing the inclusion of PBL in our undergraduate curricular reform of the course (Production Engineering)."

- Changing the mindset about engineering education:
  "It changed my view about teaching and students. It allowed to identify other teachers who seek this same goal. I became more reflective about teaching practice. It inspired me, made me dream of a new Production Engineering course for my university."

  "It brought me new ideas on how to put into practice some actions that I believe are important in the actions of the teacher and the students."

  "The workshop has changed my understanding of engineering teaching."

During the workshop the participants were challenged to create a PBL proposal to be implemented in a real context. For that reason, the participants of this study were asked about if those proposals were effective implemented and 64.2% responded affirmative. Nevertheless, 35.8% of the participants responded negative. It is possible to identify two main reasons. The first reason, is the curriculum organization which is inflexible and for that reason does not allow to create interdisciplinary environments, making it difficult to overcome some constraints (e.g. number of students, number of hours per course, etc.). The other reason is regarding to the lack of teachers' collaboration and engagement to make PBL happen.

5.2 Perceptions about *Teachers' Professional Development*

In terms of professional development, the perceptions of the participants' highlights some interesting issues that might be important for further research. For instance, after the PBL workshop 47.8% did not attend to similar workshops. The main reason I the lack of training opportunities for active learning contexts, including PBL. Among participants that continue to pursuit engineering education training (52.2%), most of them are involved in an international consortium with a Higher Education Institution from the USA, and had the opportunity to attend workshops about peer instruction, flipped classroom, team based learning, amongst other. A few participants from two Brazilian universities also had the opportunity to attend to specific activities carried out inside their institutions. Nevertheless, 74.6% of the participants attend to conferences that contribute for their professional development in engineering education, mainly because is an opportunity to do research and learn with others. There are four conferences highly mentioned by these participants: COBENGE (*Congresso Brasileiro de Educação em Engenharia* – national conference about engineering education in Brazil), PAEE (Project Approaches in Engineering Education), ALE (Active Learning in Engineering Education) and SEFI Annual Conference.

All participants highlight the importance of pedagogical training in their professional development. In fact, 83.6% consider pedagogical training as very important and 77.6% of the participants refers that they missed this kind of support in the beginning of their careers as teachers. One of the participants states that "teaching engineering should not be (considered) intuitive", in terms of preparing a class, defining the evaluation model and using active learning strategies for students' engagement. In this regard, the pedagogical training is considered an added value for teachers' professional development. These are the priorities topics presented by the participants of this study, in fact, as most relevant for their teaching practice. Nevertheless, other

topics were also mentioned, such as effective communication, curriculum design, educational management, scholarship of teaching and learning and professional profile and competences. In terms of the type of training, 71.6% of the participants prefer specific workshops where is possible to be focused in one topic. Other options were also considered, namely tutorial sessions with experts (37.3%), intensive training programs (32.8%), post-graduation programs (17.8%) and informal training with peers (9%). In terms of the way of training, 62.7% prefer a mix approach (face-to-face and distance) and 37.3% prefer a face-to-face approach. None of the participants choose an approach solely based in distance learning, which reinforce the importance of personal contact in these contexts. Besides the pedagogical training, there are also other activities regarding to teachers' professional development that may add value to teaching practice. For instance: communities of practice (working groups); organizing events related to teaching practice; and developing research groups.

6 Final Remarks

This study aimed to make a description and interpretation of the type of impact a set of 19 workshops delivered from 2010 to 2015 in higher education institutions had on its participants. Additionally, it aimed to discuss the importance of teachers' professional development based on these participants' perceptions.

Considering the findings presented, it was possible to increase the understanding about the two research questions. Regarding the impact of the PBL workshop at different levels, the participants referred impacts on their practice in the classroom, on curricular changes and on changing their mindset about engineering education. In fact, the nature of the workshop, based on an active learning environment, allows the participants to "feel" the implications of it: working under pressure, dealing with the unknown, working in teams, searching for information, amongst other competences that is possible to develop within this context. Regarding the professional development in engineering education, the lack of research on this topic reinforce the importance to develop more empirical and theoretical studies about it. In other words, it is important to understand how teachers can improve their practice in order to change how engineering students can learn. In this sense, it is crucial to discuss alternatives and opportunities for engineering teachers' professional development, particularly pedagogical training activities as presented in the findings of this study. From the participants perceptions it is possible to conclude that most of the teachers prefer training models based on specific workshops, but they are open to enrol in tutorials with experts and intensive training programs. In short, some recommendations may be considered for teachers' training in engineering education:

- Design training programs based on active learning principles, mixing face-to-face and distance learning;
- Define an approach which takes into account the teachers' constraints (e.g. lack of time for different activities: research, management, etc.);
- Explore opportunities to develop distance tutorial approaches for improvement of experiences during a semester.

This work is based on the perceptions of the respondents of a questionnaire sent to participants of several workshops developed in higher education institutions. Although the number of respondents can be considered relevant to represent the participants, the main limitation of the study is related to the fact that these respondents cannot be representative of the higher education teachers as a whole. Nevertheless, it is an important number of teachers interested in the improvement of teaching and learning processes and their participation can help to understand the type of impact a pedagogical training workshops on PBL can have on the teaching practice. Additionally, their perceptions about professional development training can be

considered has interesting starting points to develop specific sessions or programs for higher education institutions.

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