International Joint Conference on Industrial Engineering and Operations Management- ABEPRO-ADINGOR-IISE-AIM-ASEM (IJCIEOM 2020)

Current trends in Production Engineering Education: Active learning strategies

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Abstract This paper aimed to point out trends observed in Brazilian engineering education, especially production engineering, at two main Brazilian academic events held annually: Enegep (National Meeting of Production Engineering, organized by the Brazilian Association of Production Engineering), and Cobenge (Brazilian Congress of Education in Engineering, conducted by the Brazilian Association of Engineering Education). Therefore, from the quantitative survey of papers published in the annals of these congresses, between the years 2007 to 2018, it was possible to identify some trends that should be highlighted. There is an increase in research focused on active learning in engineering education, whether addressing specific methodologies or addressing the topic more broadly. The results showed the most used methodologies are Problem Based Learning (PBL) and Project-Based Learning (PjBL).

Keywords: Engineering Education; Production Engineering; Active learning.

1 Introduction

The process of organizing this paper revolves around Production Engineering teaching. From different experiences in the classroom, year by year with undergraduate students in different disciplines, problems and questions aroused reflection, reading research in the area, and, mainly, the adoption and application of active methodologies.

Engineering courses in Brazil, in general, experience a high drop-out and fail rate (Tosta et al, 2017; Almeida and Godoy, 2017; Christo et al, 2018) and, interestingly, continue to adopt similar learning models to the first teaching initiatives in this area at the end of the 18th century. In other words, the engineering field has been expanded and diversified, new technologies have emerged; social, economic, and, political contexts have changed, but the teaching-learning model of many professionals has remained

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unchanged. However, for some years now, we have seen several studies showing the need for changes in curricula and teaching strategies in engineering courses (Furlanetto et al, 2006; Dwek, 2011; Turrioni, 2017).

In 2019, the Ministry of Education (MEC) approved the new National Curriculum Guidelines (DCN) for engineering courses in Brazil. This document resulted from various society sectors' joint efforts, such as class associations, government agencies, and industry. DCN highlights the concern with a learning process that guarantees intellectual autonomy to the student, which values the use of active methodologies, the importance of learning, and skills development. In them, there is also attended with the criteria construction that can cause engineering courses to undertake innovative training. At issues brought up by the DCN, the need for graduates profile to understand, among others, characteristics of: "communicating effectively in written, oral and graphic forms", "being able to interact with different cultures, by working in face-to-face or distance teams, to facilitate collective construction "and " learn to learn" (Brasil, 2019).

To propose such comprehensive objectives, in addition to those strictly technical, we need to adopt methodologies that accompany such intended purposes. If we want to educate proactive students, it is necessary to adopt methodologies that lead them to engage in increasingly complex activities, in which they have to make decisions and evaluate results, with relevant materials support. If we want them to be creative, they need to experiment with countless new possibilities to show their initiative (Morán, 2013).

Concerned with looking for examples of initiatives that have been carried out or adopted to explore new possibilities for structuring classrooms, applied methodologies, innovation efforts, the purpose of this paper has established. This objective is to point out trends observed in Brazilian engineering teaching, especially Production Engineering, in discussion spaces promoted by important Brazilian engineering associations: Enegep - National Meeting of Production Engineering, held by the Brazilian Association of Production Engineering; and Cobenge - Brazilian Congress of Engineering Education, held by the Brazilian Engineering Education Association.

2 Background

The teaching-learning process has been developed over the past centuries, with the teacher as the main figure. The knowledge of the teacher has been considered valid and legitimate and passed on to students to memorize and, later, reproduce it. But, over the years, this process is questioned and new "pedagogies" emerged, seeking focus no longer on the teacher, but try to bring the student to the prominent position. Perhaps one of the most famous in this line of thought was the American John Dewey (Simon et al, 2014). For Dewey: "Learning belongs to the student: only he learns, and by himself; therefore, the initiative is up to him. The teacher is a guide, a director; pilots the vessel, but the driving energy must come from those who learn" (Dewey, 1979). In a way, another great educator, the Brazilian Paulo Freire, started his work sharing some similarities with Dewey's ideas, but he had been distanced over time (Simon et al, 2014). For Freire (Freire, 1996):

> (...) teaching is not transferring content to anyone, just as learning is not memorizing the transferred content in the teacher's vertical discourse. Teaching and learning have to do with the methodically critical effort of a teacher to unveil the understanding of something and with equally critical of the student to be entering as a subject in learning, in the process of unveiling that the teacher must trigger.

Therefore, we have seen several studies pointed to active learning as a pedagogical model that can lead students and teachers to deal with changes in society, in the perception of what is to educate and learn, with the new demands faced daily. For this model, "the teacher role is to put himself as a mediator of the learning process, the student as an interactor and knowledge as a result of actions and interactions" (Elmôr et al, 2019). Elmôr et al. (2019) also show to change the traditional classroom, consider several factors are necessary, but the most important is the attitude of teachers and students, wanting and agreeing

with change benefits. Also, a classroom with motivated students is great, but it can be ineffective if it does not result in learning. And yet, if students are active, but reluctant, without being involved, learning may also not occur.

To enable and encourage active learning by students, literature shows a series of methods and strategies that systematically allow activities development by the teacher (Morán, 2015; Elmôr et al, 2019; Araújo and Sastre, 2019).

It is worth mentioning, together with the implementation of changes in classroom activities planning, where another position of teacher is identified, acting as a conductor, advisor, and facilitator, to think about the evaluation form will be adopted is important. To propose new activities and maintain the old way assessing, based mainly on assessments composed of objective questions and applied at the end of long class periods and without due space for students to present in a meaningful way what they have been able to learn throughout the discipline do not make sense.

Assessment must be conceived as a resource for learning. It is a time when the teacher collects data to (re)direct teaching process: “a privileged moment of study, and not a kind of settling scores” (Moretto, 2014). This suggests the need to place more emphasis on the evaluation process.

3 Methods

From the participation, in the years of 2018 and 2019, in two of the largest annual Brazilian academic events in the area of Production Engineering and Engineering Education, it was possible to notice the increase in discussions on the topic of active learning methodologies. Together with the debate around the homologation of the new DCNs, the works presented at Enegep (National Meeting of Production Engineering, carried out by the Brazilian Association of Production Engineering) and Cobenge (Brazilian Congress of Education in Engineering, carried out by the Brazilian Association of Engineering Teaching), highlighted the importance of training entrepreneurial engineers, indicating the need to adopt new practices in the classroom that enable differentiated training, with emphasis on the development of soft skills.

The perception of the relevance of the theme led to the search for academic articles presented at such events, as well as the main actions developed by researchers who frequent such spaces for discussions. Thus, it was from the survey of works available on the websites of the events, from 2007 to 2018 for Cobenge and from 2013 to 2017 for Enegep, that the data presented in the next section of this article is constituted. The other trends presented are the result of the direct or indirect participation of the authors in the actions carried out by the entities promoting the academic events mentioned. In this work, the trends listed restrict to the Brazilian panorama configuring as a first approach to the theme. This initial work will have consequences, followed by more expanded research.

4 Current trends

As previously mentioned, this paper seeks to portray trends observed in two main Brazilian academic events held annually: Enegep (National Meeting of Production Engineering, organized by the Brazilian Association of Production Engineering), and Cobenge (Brazilian Congress Engineering Education, conducted by the Brazilian Engineering Education Association). The concern with learning and active methodologies has increased over the years, which can be seen through the number of works exhibited in these spaces.

In a preliminary survey in annals of Cobenge (Assumpção, 2019), from 2007 to 2018, there was an increase of studies addressing active methodologies, in general. In 2007, is possible to see 11 published papers and in 2018, a total of 87 documents, representing an increase of about 790% over 12 years.

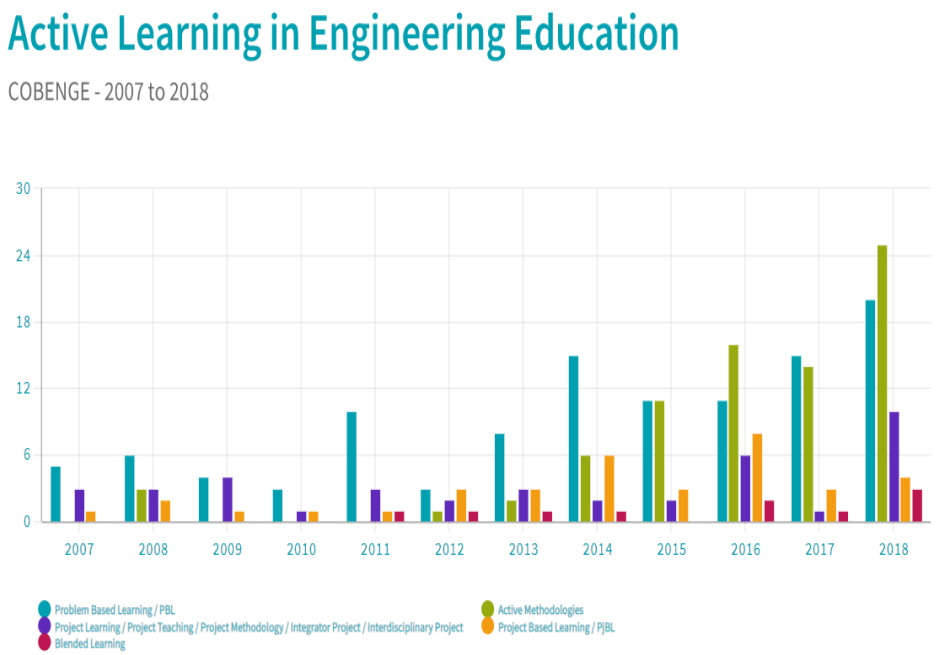

Fig. 1. Papers presented at Cobenge from 2007 to 2018 – active methodologies. (Source: Authors, based at available information in: http://www.abenge.org.br/Gt_Aprendizagem.php)

The same survey allows identifying the growth in adoption of two main methods used in engineering scenario: Problem-Based Learning (PBL) and Project-Based Learning (PjBL), which will be discussed below.

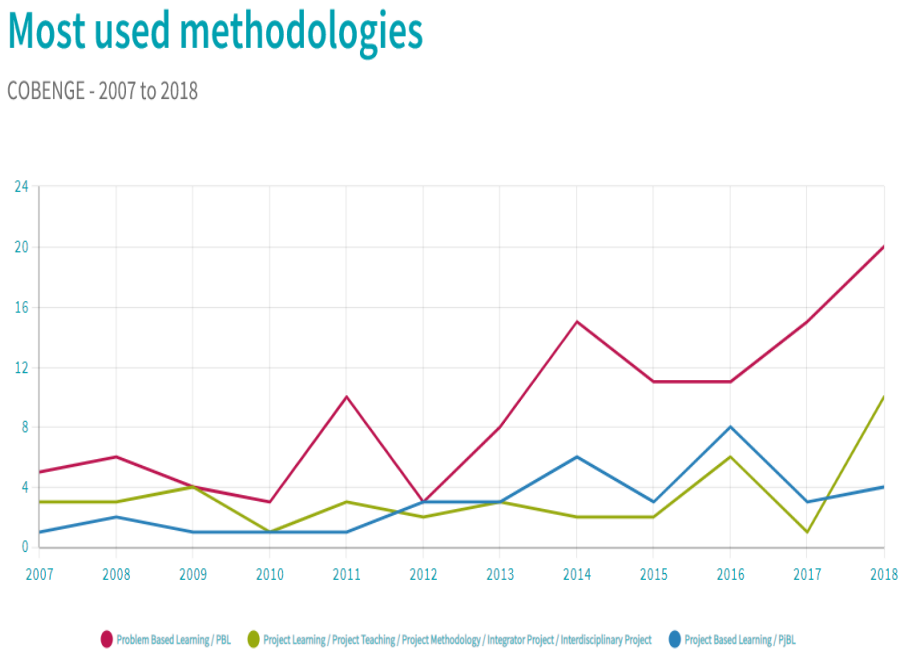

Fig. 2. Evolution of papers presented at Cobenge from 2007 to 2018 – about two main methodologies adopted in engineering scope. (Source: Authors, according to available information in: http://www.abenge.org.br/Gt_Aprendizagem.php).

5 Problem-Based learning, Project-Based Learning and ABENGE initiatives

To Fonseca and Neto (2017), active methodologies are a broad concept, which can refer to a series of teaching strategies. Among these strategies, can be mentioned Problem-Based Learning, Project-Based Learning, Peer Instruction, Inverted Classroom, Challenge Based Learning, among others (Fonseca and Neto, 2017).

Problem-Based Learning intends to lead students to learn about a specific subject through real and complex problems (Elmôr et al, 2019). "The educational concept of Problem-Based Learning removes the prospect of understanding common concepts and situates it in capacity to develop new knowledge". There are different ways of implementing the PBL, but in all of them, it is possible to find a set of activities "that start from the presentation of a problem to students, who organize their ideas, in teams, trying to understand and solve it with the knowledge they already have" (Elmôr et al, 2019).

In an analogous way to Problem-Based Learning, another method identified – Project-Based Learning – also represents an important trend because it is a teaching method in which students can have actively engaged in real Production Engineering projects. Project-based work can approach a "perspective of knowing how to achieve training in professional skills, or even with the perspective of knowing for the acquisition of methodological skills for analyzing and applying problems" (Enemark and Kjaersdam, 2009).

Project-Based Learning differs from Problem-Based Learning because it is based on the design of projects to develop transversal skills, instead of using the sequence of problems. The main difference is that for the elaboration of a project, it is necessary to have a more precise and experienced contextualization, in this way, there is a greater number of considerations to be made and more tasks (Sesoko and Neto, 2014). In addition to Project-Based Learning, it is possible to observe other implementations that vary in the number of steps and activities, in the complexity of the proposals, but whose basic principle is the creation of new products, processes, through the development of new projects (project learning, project teaching, and others).

Another strategy, the Challenge Based Learning (CBL) is part of a larger collaborative project initiated in 2008 called Apple Classrooms of Tomorrowis. CBL is an engaging multidisciplinary approach to teaching and learning that takes students to leverage the technology they use in their daily lives to solve real-world problems (Nichols and Cator, 2008).

A point to be emphasized regarding the results of the survey carried out is the emergence of Work Groups (GT) aimed at the study of subjects related to active learning within the scope of the Brazilian Association for Teaching in Engineering (ABENGE). We can find the Active Learning GT, created in 2014, with the primary objective of "disseminating the knowledge generated in the area of Active Learning in Engineering Education" and "promoting the creation of a research network in Active Learning in Engineering Education".

In 2019, Active Learning GT promoted the "1st Brazilian Symposium on Active Learning in Engineering Education", with the theme "Active Learning in Engineering Education in Brazil: Where are we? Where are we going? ". The event aimed to "Provide a forum for discussion and updating and contribute to the panorama of Continuing Education for Teachers ", having as its target audience, professors, and managers of engineering courses at Brazilian universities (ABENGE, 2019). In this sense, an interactive session "Active Learning: Opportunities and Challenges" was held with an Associate Professor at Aalborg University, a Danish university that has been adopting an academic model based on projects and problems since 1974 (Enemark and Kjaersdam, 2009). Also, several practical workshops were offered where participants could experience, in space for exchange good practices among teachers, active learning methods and strategies (for example, Problem-Based Learning (PBL), Project-Based Learning (PjBL), Team-Based Learning (TBL), Flipped Classroom, and others.)

Another Work Group promoted by ABENGE is the "Entrepreneurial Education". Created in 2016, this committee has the general purpose of "instituting a space for reflection and debate on insertion of entrepreneurial education in engineering education programs, articulating interaction with actors from academia, company, and government". This GT also intends to structure a guiding methodological guide for insertion entrepreneurial education in engineering (ABENGE, 2019). The group has been promoting seminars about entrepreneurial education since 2018. The highlight for the seminar in 2019, where

teachers from Brazilian universities were offered training on entrepreneurial dynamic learning, presenting an integrated tool (EDLE- Entrepreneurial Dynamic Learning) that has active learning as one of its pillars.

Also result of work developed at COBENGE 2019, a book organized from Directed Sessions will be launched, where it will be possible to observe the use of Digital Technologies of Information and Communication, in a stimulus to exchange, cooperation between students, supporting activities classroom and seeking to provide active learning, such as Tracker, MsProjet, SolidWork, Kahoot, and others.

About ENEGEP, some works help to understand how active learning has been dealt with in a more specific scope of Production Engineering. Santos and Figueiredo (2018) show the use of active learning methodologies in the proceedings of ENEGEP is still recent. In the period from 2013 to 2017, eight papers were identified, mainly addressing the Problem-Based Learning (PBL) methodology. The authors of these works, however, are concentrated in a few institutions in the south and southeast of Brazil (Santos and Figueiredo, 2018).

In a study on publications in ENEGEP and SIMPEP (Production Engineering Symposium) from the years 2011 to 2016, in the area of Education in Production Engineering, is interesting to note that works are concentrated mostly in the Production Engineering Teaching Study sub-area (Santos et al, 2017). Still, active methodologies do not seem to be being explored much. This situation deserves reflection since the growth of Production Engineering courses in Brazil was very high, from the years 2008 to 2017 (Santos et al, 2019). This development, it is worth remembering, was induced by a series of changes in Brazilian legislation aimed at expanding higher education in the country.

The article's relevance, therefore, can be favorably measured as a result of the entire Brazilian scenario. This panorama, eventually, differs from the horizon of more developed countries, because, as numerous researches indicate, Engineering Education is not a uniform global phenomenon (Lucena, 2008).

In addition, active learning strategies are also relevant in the face of Distance Learning Production Engineering courses. In the broad Brazilian territory, Distance Education became a preferred option and an important tool in the process of public policies in education, including on account of public universities consortia that offer quality free education (Assumpção et al, 2018).

6 Conclusions

This paper aimed to point out trends observed in Brazilian engineering education, especially Production Engineering, in two main Brazilian academic events, held annually, as they are important spaces for discussion: Enegep (National Meeting of Production Engineering , conducted by the Brazilian Association of Production Engineering), and Cobenge (Brazilian Congress of Education in Engineering, conducted by the Brazilian Association of Engineering Education).

Based on the survey carried out, it was possible to perceive, among other things, the growing interest around the subject of Engineering Education, and that studies on active methodologies are increasing over the years, including within ABENGE. Also, more specifically, there was an increase in the adoption of two main methods used in engineering: Problem-Based Learning (PBL) and Project-Based Learning (PjBL).

Trends observation such as these should serve as a basis for further research. Because, in future studies focused in the classroom, it is expected to verify relevant characteristics of these methodologies, their possibilities, and / or application difficulties, to develop proposals with viable implementation and, in accordance with the needs and expectations of students, expanding your possibilities of building meaningful learning. Moreover, this initial work will undergo developments, followed by expanded research. The investigation will include not only conference proceedings but also papers on indexed bases, to confirm whether the trends verified in the Brazilian congresses remain in publications of greater density, both national and international.

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