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Application of the Problem Based Learning Method in the Discipline 'Statistics for Engineering'

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***Abstract*—Perceiving the need for an innovative and colaborative learning environment, the use of the Problem Based Learning method provides a motivational situation favorable to learning, besides engaging students more intensely. Therefore, the students were requested to obtain the adequate solution for a proposed problem, which was related to a fictitious production line, using an experiment project. At the end of the activity it was possible to perceive not only greater satisfaction on the part of the students, but of the professor as well, in regards to the teaching/learning process.**

Keywords—Problem Based Leraning, Engineering, Experiment Project

I. Introduction

In an environment of fast development and strong competition, companies have been seeking for more and more qualified professionals, with the production engineer being a fundamental part of this group of professionals [1], [2]. The expected [3] competences of a production engineer, according to the Ministry of Education (MEC) guidelines, include the ability to use mathematical and statistical tools to project, implement and improve systems, products and processes, in order to stay up to date with technological advances, to understand the interrelation of the production systems with the environment, to work in multidisciplinary teams and to model and solve problems.

These expected competences must be developed throughout the undergraduate and graduate courses. Therefore, according to [1], it is paramount, in the elaboration of pedagogical projects, to establish relations with the market, which is necessary for any applied science intending to propose solutions for real problems. For the creation of this relation and the development of the expected abilities in an engineer, methods such as collaborative education, active learning and team work have become more and more important for students, for they allow interpersonal skills, such as the capacity to work in teams, to be developed during the learning process [4], [2].

Over the last two decades there has been a reformulation movement in engineering education all over the world, motivated by the need to engage students in the learning process [5]. In this sense, it has become important to promote activities that make the professor a facilitator of learning experiences and opportunities. This movement seeks a more active learning process, defined as any methodology which attempts to engage students in this learning. These methodologies include activities such as reading, writing, problem solving, issue resolution, promotion of discussions, among others [6].

Perceiving the constant need for change and students' and professors' demands for an innovative and collaborative learning environment, the course of Production Engineering, offered by the Federal University of Rio Grande do Sul, Brazil, is currently undergoing a restructuring period in regards to its course objectives, infrastructure, assessment models, syllabus, professor positions and, mainly, new pedagogical practices. This restructuring is founded in the belief that students may play an active role in their own learning, sharing the responsibility with the professors; that people are different and, therefore, demand different and innovative learning methods; that for a better learning, a motivating, collaborative and enabling environment is necessary; and, finally, that the education of professionals must not only be technical, but contemplate the ethical, social and environmental dimensions and also develop students' critical and systemic views. Consequently, the present research was elaborated in a favorable situation for the proposition of innovative methods of learning and pedagogical practices.

According to [7], the most used methodologies are Problem Based Learning (PBL), Collaborative Learning and Cooperative Learning. Cooperative Learning takes place through small groups of students sharing their knowledge; Collaborative Learning refers to any activity students perform together so as to achieve a common goal; and, finally, PBL is used with the introduction of problems to be solved by the students in order to motivate them in their search for knowledge [8], [9], [5].

According to [5], PBL was developed in the 70s at the school of medicine of the University of MCMaster, Canada. It is a learning methodology which has become popular in recent years. It proposes the solution of problems related to students' realities. According to [10], the main characteristics of PBL are the student-centered learning process, the use of problems that stimulate students to learn and the shift in the role of the professor, who now becomes a facilitator.

In view of the increasing interest in PBL to promote active learning, the general objective of this article is the elaboration of an educational activity inspired by PBL, used in the classroom as support for the educational experiment project, in order to assess each student's learning process. The specific goals are: (I) to plan the experiment to solve an everyday problem of the production engineer; (ii) to analyze the results obtained with the experiment and investigate which factors of a production process impact in assembly time; (iii) to assess to what extent the educational activity in the classroom impacted students' satisfaction in their learning process. It is important to highlight that the application used for this article had an exploratory purpose, aiming at identifying limitations, appropriateness and raising awareness of professors, for future and full use in the discipline statistics for engineering.

The article has been structured as such: at first, the justification is presented for the approach of knowledge in the classroom by means of problem-solving on the part of the students. In section 2, the theoretical basis is presented, with the relevant issues for the present study. Concepts on PBL and Experiment Project are elaborated. In section 3, the classroom activity applied is presented. The article is then concluded with the description of the results.

II. THEORETICAL BASIS

A. *Problem Based Learning*

Problem Based Learning (PBL) can be considered a constructivist approach methodology. It was first proposed in the 70s in medicine schools with the objective of helping students integrate clinical concepts and the development of analytical abilities and the solution of problems. However, it also called the attention of other sciences, which perceived its capacity for collaborative and constructive learning, through social interactions [11], [12], [13].

What is expected from the implementation of PBL is the students' active learning, i.e., their becoming active collaborators in the construction of their own knowledge. The approach used consists of the initial proposition of problems that must be solved by the students, so as to allow them to study the phenomena and to understand the aspects involved, to only then search for the concepts that will allow them to find the appropriate solution. In this sense, it differs from the traditional method of teaching/learning, in which classes as given mainly in lecture format by the professor [13].

Therefore, according to [14], a problem is proposed, one which is directly related to an academic or professional topic of the students' interest and to the discipline being taught. From the presentation of the problem, the students, in groups, begin with the first analysis and discussion, based on the knowledge they already possess. Then, individually, they search for new knowledge to, once more in group, widen the discussion and share with peers whatever new pieces of information they learned. Guiding the entire process is the tutor, whose responsibility is to support students in each stage of the PBL.

Among the main advantages of PBL, [13], [14], [5] identified the importance attributed to knowledge by students and a greater commitment. These authors highlight that students display more motivation in solving the proposed problems. The study conducted by [13] aims to discover the contribution of the stage of PBL in learning. With observations, interviews and questionnaires, they found that each stage of the proposed cycle in the implementation of PBL contributes to learning in a constructive way. They also highlight that the tutor's participation is extremely important in guiding the proposed activity.

B. *Design of Experiments*

As [15] claim, the consistency of the conclusions drawn from an experiment depends on how the experiment was conducted. Therefore, the statistical planning of the experiment supports the use of valuable sources in an efficient way, assuring the economy and the efficiency of the experimental process. With that in mind, the experiment project aims to optimize the experiments for the evaluation of the processes or systems which, in turn, are evaluated by performance indicators, that is, by the quality characteristics demanded by such. The systems have parameters that configure them, and when altered, they may impact the quality of the characteristics. These parameters are called controllable factors. However, there are also the parameters that may influence the performance of the system, but which we cannot control - i.e., noise factors [16].

According to the authors, several experiments involve the study of the effects of two or more factors in different levels. When all combinations of the levels of factors, called treatment, are investigated, it can be said we are dealing with a factorial project. Since there is usually more than one factor related to the characteristic of quality, translated into response variables, it is necessary to study them together in order to avoid distortions in the conclusion. Studying the effects of the factors separately might result in an inappropriate optimization when there are interactions between these factors [17, [15], [18]. [17] states that in order to answer whether there is a significant difference in the variable response due to different treatments (associated with the different levels of the factors), the best tool is the analysis of variance.

According to [15], the analysis of variance can be used to check whether there are effects of the main factors and of interactions in the variable response of a given process. The authors also highlight that whenever a significant effect of an interaction is detected, the main effects of the factors involved lose their interpretation value.

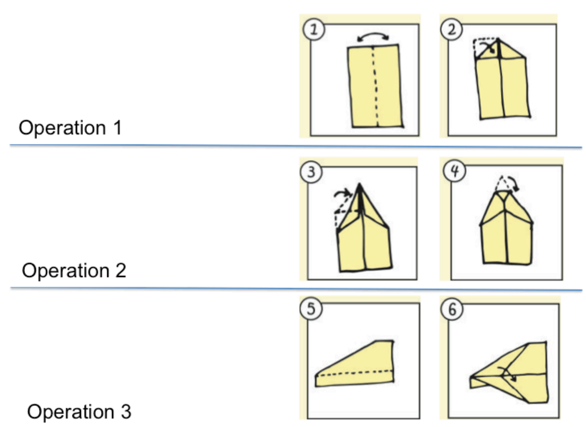
III. Activity performed

The activity proposed to the students consisted of crafting paper airplanes using folding techniques, with the assessment of the time to accomplish the task. The problem to be solved consisted of the following question: ‘Among the factors studied - original dimension of the paper, position of the operator of the assembly line and production system, which influenced the time of crafting the airplanes?’. Therefore, it was attempted to simulate a real situation for the action of the Production Engineer in the industry, in which it is necessary to identify which factors impact the efficiency and productivity of the assembly line. The activity was proposed for the discipline of Engineering of Quality, offered in the course of Production Engineering at UFRGS. It aimed to provide support to the subject of Experiment Projects in Blocks, complemented with a lecture class given by the professor of the discipline at the end of the practice moment.

The crafting of the airplanes is executed in a structured line in three sequential operations, with each operation done in a set of foldings, according to figure 1. The students gathered in teams of four, in which three were responsible for the execution of the operations of the assembly line and one for the measurement and record of the time of the task. The activity proposed considered the identification of which factors studied impacted the assembly time of the airplanes. The following factors were studied in two levels, denominated -1 and 1: original dimensions of the paper, position of the operator in the assembly line and production system. The task used paper with dimensions corresponding to ½ and ¼ of a sheet of paper; two of the ‘operator’ students took turns in their positions between operations 1 and 3; the push and pull production systems were simulated. The controllable factors and the corresponding levels are indicated in figure 2.

The students were at first requested to project the complete factorial experiment considering two-leavel factors, to be executed in two blocks, each block comprising a team. The complete experiment was performed by a couple of teams, each team being responsible for the completion of one block of the experiment. At the end of the experiment, the teams exchanged information. The response variable assessed was the time to perform the task of crafting four airplanes.

At the end of the activity, a questionnaire was applied in order to assess the impact of the activity in the students’ satisfaction and in their learning process.



1. Folding sequence to craft the airplane

Factors	Levels	
	-1	1
Original dimensions of the paper	½	¼
Operator position in the assembly line	Operator 1; Operator 2; Operator 3	Operator 3; Operator 2; Operator 1
Production system	Pull	Push

2. Factors and levels studied

IV. RESULTS

The activity allowed the students to exercise the planning of an experiment to solve a proposed problem, which exemplifies in a simple way the situations faced in the professional engineer's everyday activities. The solution developed by the students was built through peer interaction for the exchange of knowledge and experience, with the guidance and supervision of the professor in charge of the discipline and of a Master's degree student. Also, at the end of the experiment, the students were requested to reflect and discuss about any mistakes committed and problems found while performing the task.

From the point of view of who conducted the activity, it was possible to perceive greater motivation and commitment on the part of the students to study the issue at hand, when compared to the behavior observed in traditional classes - given exclusively with the presentation of a certain topic. A more proactive behavior on the part of the students could be observed as well, in regards to search for the solutions for the problem.

In relation to students' perception, with a questionnaire it was possible to find their level of satisfaction in performing the dynamic activities. An amount of 62% of the student informed being very satisfied with the application of the activities or educational games - such as the one reported in this article - in the classroom, while 38% claimed to be satisfied. When asked about the learning opportunity offered by the activity, 89% perceived benefits, while only 11% considered it to be indifferent.

Therefore, it can be noted that the use of problems and educational activities in the engineering course can provide a more dynamic and motivating environment to the student, who overcomes difficulties to find the best solution. In this context, the professor widens his field of action, since besides constructing the necessary knowledge, he guides the student in the research and in the logical decision-making process. Thus, from the study proposed, one can observe the possibility and demand for the development and application of PBL in this discipline or others that compose the Industrial Engineering course.

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