USE OF METHODOLOGIES ACTIVE IN THE TEACHING OF THE
MASS AND ENERGY BALANCE DISCIPLINE

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Abstract
Project-Based Learning (PBL) is a student-centered technique whose objectives are to develop curricular skills through a more active way, unlike conventional teaching methodology. It has been used with Lorena’s School of Engineering (EEL-USP) students in order to force them to deal with more real cases and so to adapt them to professional life with self-development, teamwork and self-learning skills. The aim of this study was to analyze the implications of the change in learning didactics, specifically in the discipline “Mass and Energy Balances” in a Chemical Engineering course, offered to EEL-USP students through the constant follow-up of a TA (teaching assistant) under the guidance of the teacher of the discipline. The follow-up took place throughout the semester, sessions with academic practices such as discussing and synthesizing ideas with the students were performed, so that they could work about specific industries and apply, through the PBL methodology, the concepts presented by the supervisor and to build real problem situations in the field of engineering. The evaluation of the applicability of the project was done through two questionnaires and the weekly follow-up monitoring. The analysis of the results suggested that it is feasible to apply this active methodology to teach Mass and Energy Balances, with certain points to be highlighted and/or changed, but the satisfaction index was about 75% of the students and the feedbacks demonstrated greater leadership skills, teamwork, time control, development of reasoning and prioritization of tasks, communication and presentation skills, problem prevention, application of technological and educational tools (internet, networking, meetings, brainstormings) that are basic requirements established by the National Curricular Parameters for the engineers in the country.

Keywords: Teaching, Engineering, Active Methodologies.

1 INTRODUCTION
The engineering education is intrinsically related to the social, economic and technological developments of the country, taking part as a reflex of factors like gross domestic product (GDP) and population. It is possible to say that, from 1991 to 2011, there was a considerable increase in the number of engineering courses. Also, after 2002, the engineering branches in the country increased, and engineers are now able to act in a wide range of jobs [1]. In a world where technology is constantly advancing and present in students’ individual and academic lives, it is noticeable that the teaching methodologies are still archaic, always faithful to the content importance, but with no significant new pedagogical teaching approaches [2].

In order to face the challenges in education, the first studies in Project-Based Learning (PBL) methodologies arise. Allied to the theories of Constructivism - which believes humans acquire their knowledge from interactions with the environment and are different for each person - and Constructionism - which beliefs are based on the elaboration of a step-by-step learning for each person and it reaches its maximum point when the information and challenges can be shared and discussed in group – the PBL methodologies arise to size, deepen, enhance and integrate knowledge [3].

The PBL methodologies can be disposed in different mechanisms, each one being adapted to the educational context in which it will be applied [4]. A PBL is a pedagogical methodology which approach a real-life problem preceding the theory discussion. It demands a formal process of problems solution, which must be made in groups. It implies students’ self-study and knowledge integration.

In this context, the present job applied the PBL methodologies in the university environment, aiming the analysis and interpretation of the implications caused by the changes in learning didactics, specifically in the discipline “Mass and Energy Balances” in a Chemical Engineering course offered to
EEL-USP students through the constant follow-up of a TA (teaching assistant) under the guidance of the teacher of the discipline.

2 METHODOLOGY

The PBL project for the discipline Mass and Energy Balances was established between the teacher and the teaching assistant before the beginning of the semester. The main project guidelines were: the classes were divided in groups of 7-8 students; each group chose a student as their leader; traditional chemical industries with easy access to information were associated to each group; the research and knowledge about the associated industry was mandatory to all the students of the group; each group developed a project approaching at least one unit operation from the associated industry, calculating the mass balance of a physical process (with no reaction) and another related to a process containing at least one chemical reaction. Then the groups presented their projects to the entire class. All the written projects were previously sent to the teacher. Besides the two mass balances, the groups also suggested a process optimization to the industries they were studying and presented it together with the mass balances. This presentation was made by one or two students from each group, randomly selected on the presentation day; after the mass balance phase, the projects continued with the energy balance phase. Similarly to the first phase, the students calculated energy balances for processes with and without chemical reactions and suggested an optimization for the process and presented them to the class. Again, the optimization part was presented by one or two students from each group randomly selected on the presentation day; the teacher and another three professors were responsible for the groups evaluation. They analyzed the written projects and the presentation, taking into account creativity, main concepts of the discipline, mathematical coherence and logical thinking. Also, the students evaluated themselves. Each group discussed together and graded each participant from -3 to 3. Two students from the same group could not receive the same grade, unless the number of students were higher than the number of available grades. No exam papers were applied.

The teaching assistant (TA) established fixed times during the week to follow-up the groups’ progress and to help students which were struggling with the project. Some of the TA activities were to clarify students about the theories associated with mass and energy balances, to discuss the project in general and to indicate reliable sources for research. Also, to measure the satisfaction index, the TA organized two questionnaires. They were all sent via institutional e-mail to the students, who could answer them anonymously. Only students with the access link were able to answer the questionnaires, providing more safety to the measurement.

The first questionnaire was sent before the presentations and should be answered individually. The questions asked the students’ opinion about the traditional teaching methods, if they knew what PBL is, and what it represents. The main question of this part asked the students about their perspectives about the project and if they thought it was possible to learn from it.

The second questionnaire was sent to the leaders after the end of the semester and should be answered in groups. All the members of the group must have consented with the answers. The questions asked the students about how much they learn about the discipline concepts compared to the beginning of the semester, the positive and negative aspects of the applied methodology and how much they learned from it, if they believed the project brought a professional reality rather than academic, how the leader managed to control the progress of the project, how many time the groups dedicated to the project and if this time influenced their final grades, to describe difficulties faced and how they managed to eliminate them, if they believe they learned more efficiently from this method rather than the traditional one and why, if the TA help was efficient and necessary, and what the groups can do to improve in further works.

3 RESULTS

The Mass and Energy Balances classes totalized 147 students during the second semester (August – December) of 2017.

3.1 First Questionnaire

The first questionnaire was sent to the students at the beginning of classes, when they already knew about the project. 108 anonymous answers were obtained.
When asked about the traditional pedagogical method, the most interesting answers showed that 56.5% of the students answered it is centered only on themselves, depending only on their efforts to be approved. Only 11.1% believed that all students can learn from this method and 10.2% believed the evaluation is fair, measuring all the aspects expected from the student, such as knowledge and teamwork. These results show us that the traditional method is not well accepted by the students, since the majority does not think everyone can learn from it and the traditional evaluation methods, such as exams, are unfair.

Only 44% of the students answered they knew what PBL is and what it represents. This shows that although students are not entirely satisfied with the traditional pedagogical method, they are not familiar with PBL methodologies, suggesting that this topic should be more implemented at universities and schools.

Showing again that the students believe new pedagogical methods should be more present in their academic lives, 79% answered that the application of the Mass and Energy Balances project instead of exams would be an effective method for learning.

At the end of the questionnaire, the students could write their perspectives about the semester and the project. Most of the students believed the method (PBL) would be better than the traditional and they expected to see it more in other disciplines. On the other hand, some students thought not everyone can learn from it, since the groups are big and eventually some people would not do the expected job effectively. This shows that although students believe new methods are necessary, the individual exam forces them to actually study. When in groups, some might take advantage of the situation and put less effort into the project than others.

3.2 Second Questionnaire

The second questionnaire was sent to the students at the end of the semester, when they had already received their final grades. The students answered it in groups. 7 groups out of 20 participated on this questionnaire.

The first question asked the students about how they have assimilated the concepts of the discipline compared to the beginning of the semester, on a scale of 0 to 5. The answers varied between 3 and 5, showing that they have assimilated more than 50% of the concepts.

When asked about the applied method in general, all the groups stated that the PBL methodology is better than the traditional one, because it forces the students to deal with real situations, improving their skills of teamwork, organization, communication, thinking and acting like an engineer. They also believed that the lectures were necessary so they could understand the main concepts of the discipline, but the project showed them how they can be applied to chemical industries. The negative aspects of the methodology, according to the students’ opinion, are the fact that not all students put the same effort into the project, the great amount of time spent in the project and their inexperience, since they were students from the first year.

The leaders were asked about their strategies to make a good job. The obtained answers showed that they all utilized technological media, like groups in social networks to facilitate the communication between the members, and also meetings, where they had brainstormings. They all delegated tasks to the team members according to their preferences and abilities. This shows that all the leaders demonstrated great leadership skills.

Some groups spent more time on the project than others, and it influenced their final grades. Also, some groups stated that time was one of the difficulties of the project, and they had to control it to make a good job. Other difficulties stated were the research, which the TA gave students the support to do it and the elaboration of an academic work, which also demanded time and help from the TA to be performed.

The most important question asked the students if they thought they learned more efficiently with this method rather than the traditional one. A satisfaction index of 75% was obtained. These groups all agreed that the PBL method forces them to learn from real situations and improves important skills, such as oratory, teamwork, time control, communication and problem prevention, which are, in fact, what industries desire from their engineers. The other 25% of the groups still think the traditional method is better or agree that PBL is a good tool, but it is weak in terms of assimilation of the concepts. This result shows that the PBL is well-accepted by students.
About the TA follow-up sessions, all the students agreed it was very important to the project, since the teacher did not have available time to do it during classes.

Finally, the groups were all satisfied with the grades they received and believe they can do better in further works due to the skills they improved in this project.

4 CONCLUSIONS

With all the presented aspects and obtained answers, it is possible to highlight the following conclusions: the students’ assimilation with the method and the industries fitted into the semester, demonstrating that it has an easy comprehension and adaption and fast response; on the last questionnaire, the students had already received their grades, and it was answered anonymously. Therefore, it cannot be classified as coercive; from the negative points stated by the students, it is possible to highlight the bad task division present in some groups, with members working less than others. This can be corrected with a more organized follow-up, for example, at the beginning of the lectures every week. Another suggestion is the reduction of the group members to 4 or 5. There would be a better amount of work to all the students: the PBL methodology can be applied to Mass and Energy Balances classes, since most students are unhappy with the current applied methods and they learned effectively from the new method. Also, the satisfaction index was high. The PBL improves students’ skills such as leadership, organization, logic thinking, organization of ideas, teamwork, communication, task division and time control, which are basic requirements established by the National Curricular Parameters for the engineers in the country.

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REFERENCES


