ADOPTION OF JUST-IN-TIME TEACHING, PEER INSTRUCTION AND PROBLEM-BASED LEARNING – IMPACTS ON ENGINEERING STUDENTS PERFORMANCE

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ABSTRACT

The present educational system determines the amount of time students must spend in class, not the time required to master the content, so that many students are forced to move to the next subject along with the other classmates, not when they are ready to do so. This article presents an example of the actions developed by a group of teachers/professors from the Dom Bosco Educational Association - AEDB, a private educational institution located in the city of Resende/RJ, Brazil, to reduce these gaps, through the use of Active Learning Methodologies. Fundamentals of such methodologies are presented, focusing in Just-in-Time Teaching, Peer instruction, and Team-based learning. Their effectiveness are assessed through exam results comparison: Undergraduate students who are taking Transport Phenomena course with such methodologies had exams results significantly better than previous classes submitted to traditional teaching strategies. A survey was promoted to assess students’ acceptance in regards to the changes implemented in the course. Their perception is that the debates promoted in the Peer Instruction are important to the learning process of students. The same happened in regards to the video lessons and Quizzes, expressing their preference for the active learning methodologies.

Keywords: Just-in-Time Teaching. JiTT. Peer Instruction. PI. Team-based Learning. TBL.

1 Introduction

Cognitive scientists, neuroscientists, educators, and education researchers get frequently involved in debates on unique needs for one’s learning. However, the consensual understanding is that each student learns at a different pace and teaching support is required at different moments (Horn and Staker 2014), because people have different skills and different levels of prior knowledge of a subject or discipline.

Personal experiences and beliefs, teaching expectations, and the perception about how relevant is to a specific subject determines how each person will learn. Nevertheless, higher education institutions tend to ignore such differences, perhaps based on a fallacious assumption that all students evolve at the same pace and that the course content should be covered anyhow, regardless of students’ level of comprehension, which leaves behind whoever is not able to follow the established pace.

The present educational system determines the amount of time students must spend in class, not the time required to master the content, so that many students are forced to move to the next subject along with the other classmates, not when they are ready to do so. In this way, usually there is a mismatch between needs and interests: teachers have the perception that students are increasingly less interested in studies and, at same time, do not recognizing their authority (SANTOS; SOARES, 2011).

The authors infer that the current school configuration does not meet students’ real needs, causing lack of interest in the school, in the content and in the way teachers conduct their classes.

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The present study purposes to present the actions deployed by a group of teachers/professors from the Dom Bosco Educational Association (AEDB), a private educational institution located in the city of Resende/RJ, Brazil, to reduce these gaps, making use of the so-called Active Learning Methodologies, assessing their effectiveness through trend evaluation of undergraduate students’ exam results, as well as through students’ perception measurements.

The next paper sections are as follows: “Theoretical framework” comprises the fundamentals of active learning methodologies, presenting concepts, tools and methods. Also, a brief literature review of those themes is presented; “Procedures and Techniques” presents the research methodological steps; “Results” reports the use of such methodologies in an Engineering class, followed by the results of this process. Finally, “Conclusions and Remarks” assess and discuss the research findings and next steps, followed by additional research suggestions.

2 Theoretical framework

Freire (2011a) argues that “there is no teaching without learning”, i.e. the mere information transferring with no proper reception would not characterize an efficient and effective teaching-learning process. However, the traditional education model focuses on teaching, with teacher (trying to) assert his power over the student (NAGAI; IZEKI, 2013).

Seeking to reverse such scenario with flipped-class strategy, the first contact of the student to the class content moves to pre-class activities: usually using IT gadgets, students choose where and when to get access to the class subjects and, later, in the classroom, the focus moves to the discussion of the fundamental concepts and doubts’ elucidation, thus reversing the traditional classroom, in which the content is transmitted first in the classroom and deepening is up to the student to make happen at home. In other words, in traditional education process, the student is exposed to the subject content for the first time in the classroom and he/she is supposed to absorb and master the knowledge after the class (usually through his/her lonely effort, studying by him/herself), while in the hybrid education process, an integrated learning experience (Horn and Staker 2014) enabled by IT, the first contact with course subjects happens before class and, once student is aware about the subject existence and its fundamentals, learning and knowledge absorption will happen in the class through conceptual discussions and practices.

Due to such learning sequence inversion, this teaching model is called inverted classroom or flipped classroom, in which, according to Rossi (2014), students take an active approach to learning, while teachers become process facilitators and coaches (Mazur, 1997), corroborating with Freire (2011b), who argues that educators and students are supposed to continuously recreate the knowledge.

Thus, active learning takes place when the student interacts with the study subject - listening, speaking, asking, discussing, doing, and teaching - , being encouraged to construct knowledge rather than receiving it passively from the teacher. In an active learning environment, the teacher acts as a mentor, supervisor, facilitator of the learning process, not only as a unique information and knowledge source (BARBOSA; MOURA, 2013).

Rocha and Lemos (2014) highlighted the similarity between active learning methods and the concept of “pull production” in production facilities: while productive resources are used to produce what, when, and as much as is demanded, students are urged to seek solutions and answers from their own knowledge and interaction with the environment (Ahrari et al., 2014), developing skills to correlate theory to the real world (Pinto et al. 2012), i.e. in the active methodologies, students “pull” the education according to their needs, interests, preferences and pace. In this scenario, if no proper assimilation of knowledge had occurred, a demand for teacher intervention and help is generated, on time, amount, and deepness as required by the specific student needs.

According to Lemos, Rocha, and Menezes (2015), such educational approach is based on the constructivist, a theory from Jean Piaget (1896-1980) and Lev Vygotsky (1896-1934), that
argues that humans generate knowledge from interactions between their experiences and ideas; and also based on X and Y theories of Douglas McGregor (1906-1964) in which efforts to work are natural, being a matter of human being motivation to be able to learn, to devote himself to exercise imagination and be resourceful to solve problems.

Rocha and Lemos (2014) listed and detailed several models of active learning methodologies such as problem-based learning (PBL), project-based learning (PjBL), challenge-based learning (CBL), inquiry-based methodology, case methods and case-based methodology, game-based learning, research-driven web-based learning, simulations, Just-in-Time Teaching (JiTT), peer instruction (PI), and team-based learning (TBL). The last three ones are detailed ahead, as focus of interest in this study.

2.1 Just-in-time teaching (JiTT)

The Just-in-time method used in industry combines high-speed communication and rapid distribution system to increase organization’s efficiency and flexibility (Krajewski, Ritzman, and Malhotra 2009). JiTT combines high-speed web communication with the ability to quickly adjust content in order to meet specific students’ needs in a specific class. The key element is the intertwining of the activities performed in the web and those developed in classroom, i.e., the feedback to the student’s about the reading materials (NOVAK et al., 1999).

It consists of the prior class material reading and activities, providing, before the class, a feedback to the teacher about students’ level of knowledge/understanding. The method provides to the student the opportunity to check their own understanding along the pre-class reading, helping them recognize when they do not understand a concept, i.e., when they are unable to answer a question, or when they cannot give full explanations for their peers during the discussion in the classroom. With this internal feedback, students can learn to better assess their own understanding during the learning process, encouraging them to take responsibility for their own learning. At same time, student responses allow teachers to better prepare class dynamics, as they get aware of students’ difficulties and concepts with good understanding and comprehension (WATKINS; MAZUE, 2010).

2.2 Peer instruction (PI)

In this process, students learn from debating with each other the responses to conceptual multiple choice questions (ConcepTests), which are created to ascertain students’ difficulties and instigates student to think about challenging concepts. The technique promotes interaction in the classroom and engages students to address critical aspects of the course. In STEM (science, technology, engineering, and mathematics) courses, it has been recognized as an effective way to engage students in the classroom and in the laboratory (CROUCH; MAZUR, 2001; CROUCH et al., 2007; LASRY; Mazur; WATKINS, 2008).

After a brief teacher’s presentation of the ConcepTest, the focus shifts from him/her to the student: prior to showing to the student some type of experiment and its results, students are asked to predict what is going to happen, i.e. the experiment results. According to Mazur (1997), asking students to predict the outcome of an experiment promotes greater understanding of the concepts involved in the experiment. After a minute or two to think, students provide individual responses. After that, students are required to discuss their answers in small groups, and are encouraged to find different answers. The teacher moves around the room to encourage productive discussions and lead the students’ thinking. After some minutes, students respond again to the same ConcepTest.

Moving forward in the content will depend on the class real-time results, i.e., the percentage of correct answers (CROUCH; MAZUR, 2001; CROUCH et al., 2007; LASRY; Mazur; WATKINS, 2008).
The teacher informs the correct answer and, depending on the student responses, class pass through another ConcepTest, related to the same subject, or move to a different topic (Watkins; Mazur, 2010), as shown in Figure 1.

![Figure 1: ConcepTest- PeerInstruction](image)

Adapted from (LASRY et al., 2008).

A critical success factor in PI is to choose the most appropriate ConcepTests to the class, i.e. the degree of difficulty and question level (Mazur 1997). For this, the Just-in-time Teaching presents a useful tool.

Flashcards (raised by the students to indicate their response) or clickers (wireless response portable devices) are used to collect ConcepTests students’ responses and measure their performance in real time. The choice of one or the other does not interfere with the student’s learning process, since the PI is a pedagogical and not technological tool that engages students and challenges them to develop conceptual thoughts (LASRY, 2008).

### 2.3 Team-based learning (TBL)

In TBL students are organized into permanent groups and the course content is divided into large units. Before class, students must study specific materials previously distributed by the teacher. Then, groups discuss the key ideas of the studied content, reaching a consensus on the answers as a team. Students receive immediate feedback on the team responses. If applicable, they have the opportunity to write appeals based on valid arguments in regards to their wrong answers.

The final step of the process is a short and focused teacher lecture, useful to clarify any misconceptions that become apparent during the team’s test and appeals. The remainder of the learning unit is used for tasks that require students to practice the learned content.

### 3 Procedures and techniques

This topic describes actions taken to redesign the Transport Phenomena (FENTRAN) course with active learning strategies, detailing tools, processes and class dynamics and routines implemented.
After some pilot actions in 2014, JiTT and PI were implemented in Production Engineering class at the beginning of the 2015’ school year (school year in South hemisphere runs between February and December).

Study material has been previously made available to the students: as proposed by Mazur (1997) and Novak (1999) bibliographical notes, divided into class topics, were provided to the students. Besides that, video lessons for each class day were recorded and released to the students. Those videos were to be viewed by students along the week before the class day.

Up to three days prior to the class, an online questionnaire called “pre-school activity” of the content was made available and students must answer it up to the day before the class. For this activity we used the starQuiz testing software version 3.5.1. The software enables teacher to access the answers of each student, as well as a class report for each question, and students’ doubts and comments (as shown in Figure 2). Based on the students’ doubts and questions and their performance according to the report, the teacher defines the strategy to each class.

As recommended by Mazur (1997), the teacher would give a short lecture on the subject, addressing the main doubts and misconceptions of students, based on the pre-school activity performance. After the lecturing, the ConcepTest would be applied to assess students’ understanding. These tests involve core concepts and doubts or misconceptions detected through pre-school activity feedback.

In order to have an easy, fast and low cost data collection, students answered ConcepTests using plickers (card with a unique visual code, hold by students with the chosen answer positioned at the top position), in lieu of flashcards and clickers. With a Smartphone application, the teacher can scan the class, so that cards are read, identified and registered, capturing the answer that each student choses. The teacher is able to check in no time the response of each student in the room and gets a performance summary of the whole group, as shown in Figure 3.
As previously explained in the topic 2.1, the teacher decides the next class step based on the class performance, following Lasry, Mazur, and Watkins (2008) and Mazur (1997) guidelines. If performance scores below 30%, gives complementary lecture and explanations about the subject; if performance is between 30% and 70%, ask students to discuss their responses with nearby colleagues with different opinion and then respond again; and if performance is above 70%, move to the next subject.

After the whole course content planned for the first two months was covered, a content review activity was scheduled and performed. Students were divided into groups with no more than four classmates each. Groups were encouraged to solve a set of exercises and problems involving concepts that have been studied. In this activity we used IF-AT (Immediate Feedback Assessment Technique) forms, a multiple-choice learning and assessment system developed Epstein Education Enterprises, shown in the Figure 4.
The forms configuration allows students to continue answering a question until they discover the correct answer. The student scratches off the coating of the rectangle corresponding with his/her first-choice answer, as if scratching a lottery ticket. If the answer is correct, a star or other symbol appears somewhere within the rectangle indicating he/she found the correct answer, moving on to the next question. If incorrect, the student scratches off a second or even third choice until the correct answer is identified (Epstein, n.d.).

Such tool enables students to get immediate feedback about the accuracy of their answers to each question in a test/quiz/homework assignment, etc. Besides that, students never leave a question without knowing the correct answer.

After a group has exhausted the possibilities, the teacher can explain to them the concepts involved in the wrong answer(s), so that the group can move on. The student will earn partial credit for multiple attempts and learn the correct response for each question while taking the test (Epstein, n.d.).

4 Results

Upon starting the active learning practices in the FENTRAN course, results were collected: initially, students’ routine, followed by exam results comparison and, finally, students’ perception. In the pre-class activity on-line questionnaires, a question about student routine checked whether he/she had watched the related video and read the handouts. Results show a jump from the very first class and on, as seen in Figure 5.

Figure 5: Students watching video and handouts prior to activity

![Percentage of students who watched "video lecture" or read handout](image)

After that, a survey collected Transport Phenomena course students’ grades from 2010 until the year 2015, comparing their Q1 exams in Production Engineering classes. The average class grade was calculated for each class in each year. As shown in Figure 6, the 2015 class (the first one to be involved in active learning methodologies) had a better performance than the preceding classes.

Figure 6: Student exam results (1st quarter average)

<table>
<thead>
<tr>
<th>Class</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year attended</td>
<td>2010</td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
<td>2015</td>
</tr>
<tr>
<td>discipline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.2</td>
<td>3.0</td>
<td>3.5</td>
<td>4.4</td>
<td>4.1</td>
<td>6.8</td>
</tr>
</tbody>
</table>
The suggested hypothesis is that this performance difference is due to the change in pedagogical approach adopted by the use of active methods, i.e., the applied active learning methodology is more effective than traditional methods previously used in the same school.

In order to check students’ acceptance in regards to the changes implemented in the course, a survey was promoted. Students anonymously expressed how they felt about some factors, as shown in the Figure 8. Based on their responses, it can be inferred that the debates promoted in the Peer Instruction are important to the learning process of students. The same happened in regards to the video lessons and Quizzes. When assessing whether they would prefer to keep the changes (i.e., maintain the active learning processes) students indicated overwhelmingly that they preferred the new learning system, using the PI and JiTT.
5 Conclusions and remarks

The pilot application described in this article indicates the pedagogical potential of active learning methods to promote a better student learning environment. Such tools and practices must be used in a structured way, adapted to local needs and implemented through a dialogical relationship with the students.

It was shown also that the difficulties usually reported in the literature for active learning methodologies implementation are not inexorable. The pre-class study was not considered a big deal, nor was it necessary to use costly technological tools. With a “course design” well defined, with rules previously agreed with the students and a detailed schedule of activities and teacher commitment, the application of active methodologies described in this article enables new directions for learning, since it was possible to cover the whole planned course content, develop skills and competencies usually not well worked in the traditional Transport Phenomena course configurations, such as teamwork, dialogue, time management and activities’ scheduling, etc. It also frees spare time to approach multidisciplinary matters, often suggested by the students themselves.

The determination was to continue the study, since it is an ongoing process to verify if the excitement and engagement of students in activities will remain, or if such virtues are due more to novelty than to the effectiveness of the pedagogical approach.

References


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