Problem Based Learning: An Experience in Computer Engineering

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Abstract

Following the introduction of new methodologies focused in the improvement of student´s outcomes. The PBL model (Problem-based learning) was applied to support the teaching and assessment on a topic of statistics in the curricular unit Computational Mathematics. The aim of the proposed approach was to enhance the student development, by improving practice in the field of education and connections between research and practice. Following these guidelines we propose a practical work using the MS Excel, as the computational support, to 394 students of the Curricular Unit of Computational Mathematics (MATCP) of the course of Informatics Engineering of the Institute of Engineering of Porto, to be done in groups under the theme "Simple Regression and Linear Correlation". In order to verify the receptivity of the students exposed to the proposed, a questionnaire was elaborated focusing on understanding and acquisition of the proposed contents method. Some conclusions were drawn.

Keywords: Problem-based learning, Student development, Correlation and linear regression, Survey

1. Introduction

The labour market has been hiring engineers primarily for solving workplace problems; therefore problem solving skills are an essential requirement of an engineering education. Nevertheless in the real world problems are quite different from the academic ones. The aim of engineering education, is preparing the future of the students so that they will be able to work in enterprises. In this context the challenge in teaching a PBL method is creating strong problems that lead students to realize the intended course learning outcomes and the students apply their knowledge in the engineering market.

The primary role of a teacher is to facilitate group process and learning – not to provide easy answers. By renounce the control of answers, teachers are able to learn with students, and they often find renewed interest and excitement in teaching. The objectives of this project are to implement new processes of teaching/learning in engineering, being able to have new graduate engineers with a wide vision of issues related to their study/profession, in order to acquire critical thinking in real cases and to assess knowledge in linear regression and correlation; assess the impact of PBL mmethodologies over traditional learning in the curricular unit of Computational Mathematics.

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In recent decades, the teaching of statistics has been integrated, increasingly, in schools and universities, not only for its instrumental character, but also for its importance in the development of statistic reasoning in society. This happens since society has been characterized by the proliferation of information and the need to take decisions. Among the fundamental concepts are statistical linear regression and correlation. From prehistory to the present day, the discernment of the relationship that may exist between two successes has been an important aspect of human knowledge (Castro, 2012). From the words of Crocker (1981) one can infer the value that it has for Citizens the domain of the concepts of " regression and correlation " knowing whether the events are related and how intensively they do it, makes it easier for people to explain the past, to control the present and predict the future.

2. Some Recent Works

Students having learned through the experience of solving problems, can learn both content and thinking strategies. Problem-based learning (PBL) " a pedagogical approach which uses cases and problems as the starting point for acquiring the desired learning objectives" (Walsh, 2005) is an instrumental method in which students learn through facilitated problem solving.

Also is an instrumental approach that challenges students to work collaboratively in small groups of 5-10 students to find solutions to real-world problems (Azer, 2001; Baker, 2000; Barrow, Lyte, & Butterworth, 2002; Barrows, 1998; Camp, 1996; Hmelo-Silver, 2004; Margetson, 1998; Morrison, 2004; Wood, 2003). Students work in collaborative groups to identify what they need to learn in order to solve a problem. They engage in self-directed learning (SDL) and they apply their new knowledge to the problem and reflect on what they learned and the effectiveness of the strategies employed, Figure 1 represents the six steps of the PBL model.
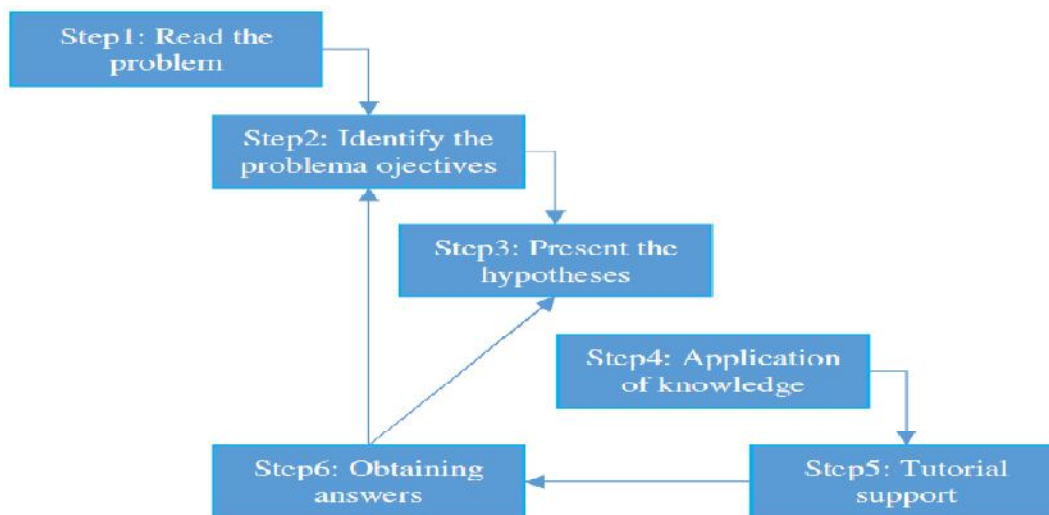

Figure 1: Cycle of Methodology PBL

The teacher acts as facilitator to guide student learning through the learning cycle. First the problem is analyzed after being formulate, of course, and the relevant parts must be identified carefully. The identification is a great help so that students know exactly the necessary information to begin their work. After identifying the problem, collecting data and select the path/paths to obtain the solution, you must begin to see that the problem has shortcomings. What is the best way forward, the shortcomings of our knowledge are the issues of learning and are becoming students into research questions (part of the learning process) during the process of self - directed learning (SDL). After the SDL students pass to the next level of their learning cycle: SDL - application of new knowledge - evaluation of hypotheses - compared to what has been learned.

The conclusion will be drawn after the students have reflected on the abstract gain. The teacher's role will be to help them to use their cognitive abilities necessary in order to get going the right way to solve and collaborate. Students at this point often not yet know how to manage objectives, learning strategies, are self - directed to solve illstructured PBL problems (those without a single lifelong learning).

Some works have been done since 1960, about the implementation of PBL model. Harold Barrows (medical educator of McMaster University) observed that the medical students and the expert practitioners demonstrated reasonable capabilities with the PBL. In 1986 Barrows developed taxonomy where he identified different types of PBL: lecture based cases; case-based lectures; case-method; modified case-method and problem-based learning.

The authors (Savin-Baden, 2000, 2007) proposed different models of PBL covering the objective of PBL, and include the perception of knowledge, learning, problems, students, the teacher roles, and the assessment. These models conceptualize five different aligned models of PBL practice, although the starting point is clearly the epistemology of the problem. Savin-Baden's five PBL modes are: attainment of knowledge, PBL for professional work, PBL for interdisciplinary understanding, PBL for cross-discipline learning and PBL for critical competencies. Comparing to (Barrows, 1986) those models are rather comprehensive and encompass indirectly an alignment of the various elements in the model. They stress that it is not possible to have, for example, open-ended problems that address knowledge objectives such as propositional knowledge. The learning objectives have to be aligned with the correct types of problems, learning processes, as well as facilitator roles and assessments.

Some works explore the problem based learning in engineering education: (Jonassen, Strobel, & Lee, 2006) made some research between the differences of traditional problems that students solve in the classroom and problems engineers solved in the real world. (Arlett, Lamb, Dales, Willis, & Hurdle, 2010) studied the motivation factors in problem based learning in six case studies across different universities. (Yadav, Shaver, & Meckl, 2010) studied impact in medical engineering as case-based teaching conceptual understanding and attitudes relating involving students. (Lamancusa, Zayas, Soyster, Morell, & Jorgensen, 2008) investigate approaching real problems that occurred in our days using several teams and active learning.

(Bittencourt, Rocha, Duarte, & Santos, 2011) applied this methodology to the course of computational engineer of the Stadual University of Feira de Santana Bahia, with success, clarifying that many teachers must be very well prepared and involved with the course and the method. (Escrivão Filho & Ribeiro, 2009) implemented a partial approach of the PBL methodology in an unique discipline. He concludes that the assessment of PBL from the students was positive (90%) and the professor evaluation shows the method is a very alternative of learning/education.

3. Pedagogical Evaluation

In the academic year of 2012/2013, in the curricular unit of Mathematics Computational, first year of Informatics Engineering , for the introduction of the proposed subject there were taught one lecture and tutorial classes of two hours each, in the subject of linear correlation and regression. By applying this methodology (PBL) the student is responsible for his learning, for his capacity of developing research and is study (Figure 2).
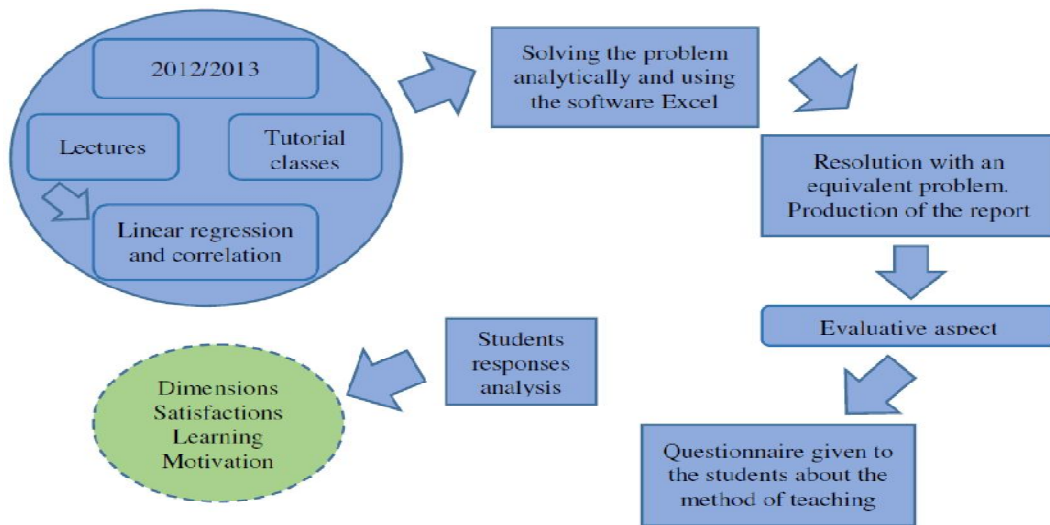
Figure 2: Schematic Representation of the Various Stages of the Learning Process

To achieve the proposed objectives the Moodle platform was used. A problem (Figure 3) was put, under the topic of linear regression and correlation.

The students organized themselves in groups (3/4 elements) and should validate the obtained results using the analytical resolution versus the computational one (using Excel software). As a challenge, in order to stimulate their critical thinking and autonomous investigation, it was suggested that they should replace the given problem for an equivalent one with a real basis, relating two statistics variables relevant where one can't identify a common cause to relate them. To develop, stimulate, enhance the critical thinking, the students were encourage to seek equivalent problems, looking for sources of information (magazines, databases, etc …) and produce a credible report mentioned the resolution of the proposed problem and the appropriate conclusions. Based on a constructivist, and in order to encourage the students to develop a critical thinking and problem-solving skills and acquire knowledge about the concepts of the topic, the PBL methodology (Woods, 1996) was used.

Proposed problem

A study was performed in a university relating the average sleep time with the average of the marks obtained at the end of the school year, adapted from (Gama & Pedrosa, 2004).

Mean sleeping time (hours)	Average rating (val)
7.a	12.a
8,8	14,4
8.b	14.b
6,8	12,5
4,6	9
8,3	14
7,9	13,2
4,5	10,6
5,5	11,3
5,4	10,2

a) Represent the data in the diagram of dispersion. Assuming the model of simple regression is the appropriated one: Estimate the linear regression line and draw it on the chart.

b) Calculate the sample linear correlation coefficient **r**. Interpret this value.

c) Using the regression model estimates the classification of a student who sleeps on average, 6.a hours.

Note: Calculation of the coefficients **a** and **b**:

Once the groups are formed students will calculate the number **T** adding their registration numbers. After that, the units digit of **T** corresponds to the coefficient **a**, and the tens digit corresponds to the coefficient **b**.

Figure 3: Task Enunciate

The use of team work group was done so that the teachers could take a conclusion about the students' behaviour in such a context, how would their performance be in the end, would their apprenticeship of linear regression and correlation be easier with tasks divided by the group? In a universe of 394 students enrolled in the subject, around 257 made the proposed work in a total of 77 groups.

The work had a weight of 20% in the final grade. Issues relating to the problem should be solved in two different ways, by analytical means and by via computational with the help of software MS Excel: add "data analysis">"regression".

3.1 Motivation

To evaluate this methodology a survey (anonymous and optional) was made with a purpose of picking up the opinion of the students about the concepts of linear regression and liner correlation. Therefore the students were able to identify facts, generate ideas and learning issues as well as reflect on concepts. In this way we encourage the study and learning the concepts. Applying the PBL, made us leading the students to change from an ill-structured problem to well-structured, and giving them a correct idea of real engineering problems. This survey is presented in Figure 4.

Survey

Questionnaire about the teaching method for understanding the concepts of linear regression and correlation in the curricular unit of MATCP.

1. Is this the first time I'm enrolled in the discipline.
   - o Yes
   - o No
2. Have I learned the concepts of linear regression and correlation in the lectures
   - o Disagree completely
   - o Disagree
   - o Neither disagree or agree
   - o Agree
   - o Fully agree
3. The knowledge acquired in the lectures was sufficient to solve the proposed problem.
   - o Disagree completely
   - o Disagree
   - o Neither disagree or agree
   - o Agree
   - o Fully agree
4. Using Excel to solve the problem was useful.
   - o Disagree completely
   - o Disagree
   - o Neither disagree or agree
   - o Agree
   - o Fully agree
5. The teaching method for the acquisition of these concepts was interesting.
   - o Disagree completely
   - o Disagree
   - o Neither disagree or agree
   - o Agree
   - o Fully agree
6. I prefer this way of teaching rather than the traditional one.
   - o Disagree completely
   - o Disagree
   - o Neither disagree or agree
   - o Agree
   - o Fully agree
7. I recommend the method teaching/research as the teaching method.
   - o Disagree completely
   - o Disagree
   - o Neither disagree or agree
   - o Agree
   - o Fully agree

Figure 4: Survey about the Work

4. Result Analysis

4.1 Analysis of the Survey

To investigate whether the responses were influenced by the fact that the student have already attended the course, two sub-sets were created, one composed of 105 students (76.6%) who attended the course for the first time and another with 32 students (23 4%) composed of students who had attended the course (Figure 5).
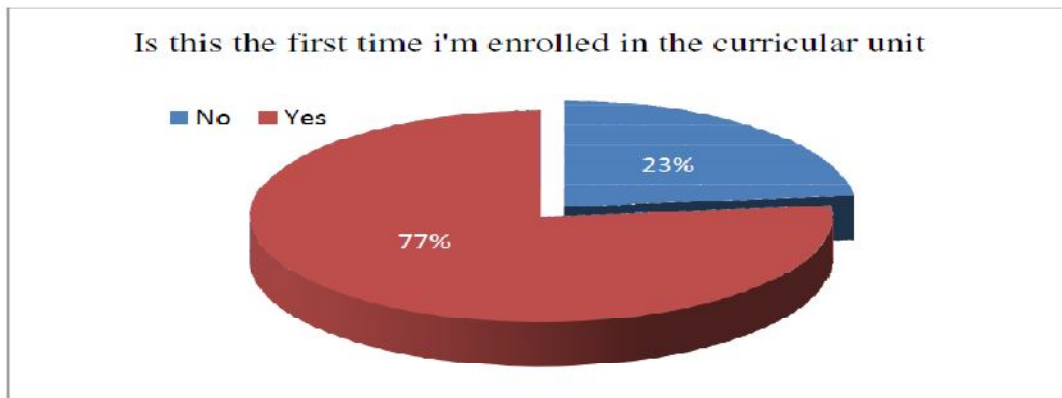
Figure 5: Registration for the Course

From these sets six Mann-Whitney Tests were performed, one for each question. The results (Table 1) revealed a significant difference only as it relates to the usefulness of the MS Excel in solving problems, and those who attended for the first time the discipline they most value the use of the MS Excel. In other questions, the test result does not allow to conclude that the sample difference is significant and so it cannot be extrapolated to the population.

	Have I learned the concepts	The knowledge acquired in the	Using Excel to solve the	The teaching method for the	I prefer this way of teaching	I recommend the method
Mann-Whitney U	1482,500	1444,000	1208,500	1402,500	1592,000	1678,500
Wilcoxon W	2010,500	1972,000	1736,500	1930,500	2120,000	2206,500
Z	-1,075	-1,262	-2,594	-1,576	-,474	-,008
Asymp. Sig. (2-tailed)	,282	,207	,009	,115	,635	,993

a. Grouping Variable: Is this the first time I'm enrolled in the curricular unit

Table 1. Test Statisticsa

Regarding the acquisition of theoretical concepts of linear regression and correlation, it was found that 10.9% of respondents indicated that no students have acquired the contents (Figure 6). Included in this group, are students who have not completed the theoretical and / or have acquired these concepts outside the classroom lessons (eg Moodle, and other sources). Moreover, 55% of the students revealed that the lectureswere sufficient for the acquisition of concepts. About 34% of the students expressed no opinion.
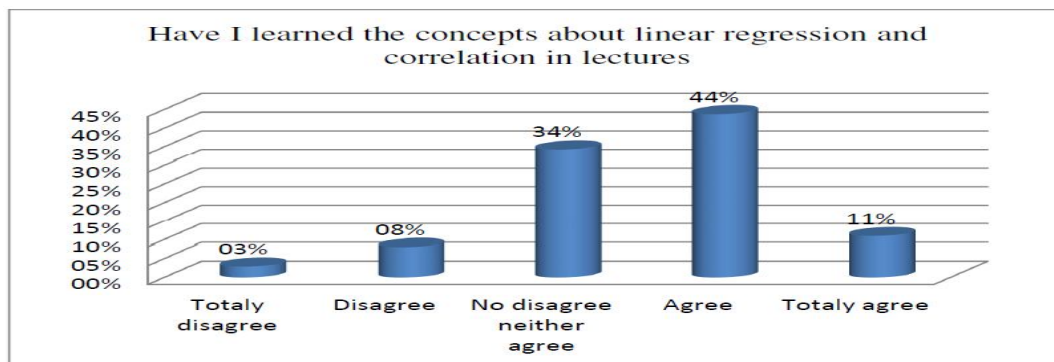

Figure 6: Learning of Concepts

Concerning the theoretical content taught to solve the problem it was found that 19% of respondents revealed that the knowledge acquired in the lectures was not sufficient to solve the proposed problem (Figure 7). Included in this group, students discussed issues on the border of the scope of the course. Moreover, 46% of the students revealed that the lectures were sufficient to solve the problem. About 35% of students showed no opinion.
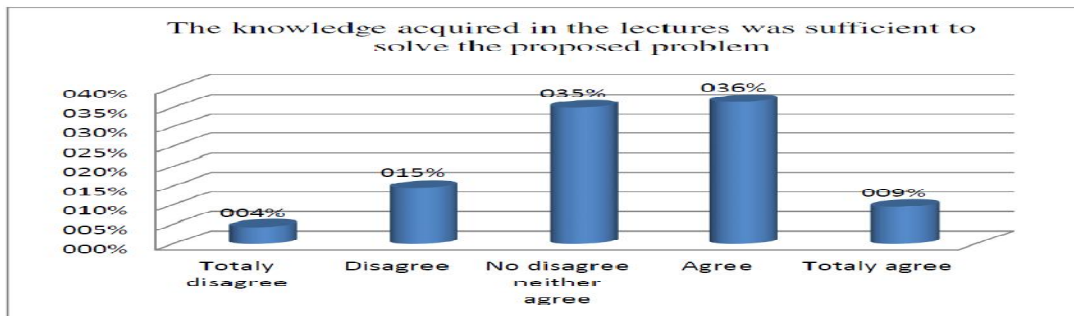
Figure 7. Knowledge acquired

The evaluation of the computational tool by the students revealed that 78% of students recognized the usefulness of the suggested computational means (Figure 8). This result is consistent with the profile of the student computer engineering.
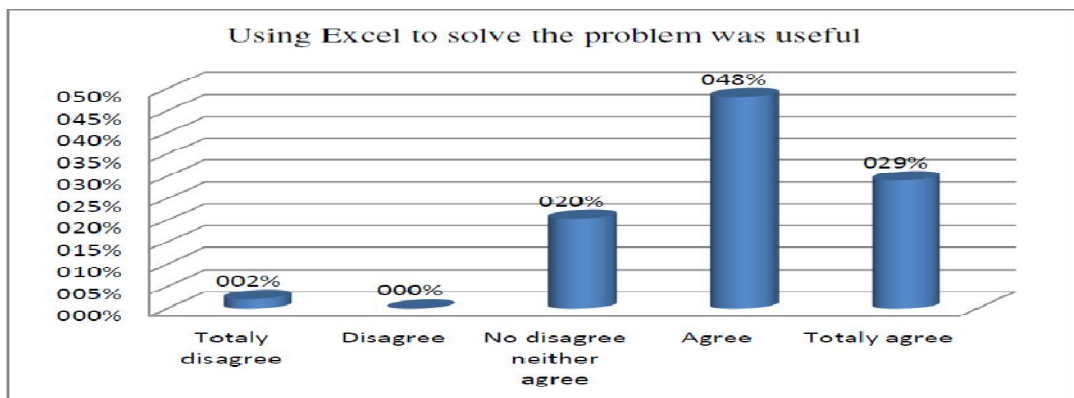

Figure 8. Using Excel

With regard to the interest of the teaching method (PBL), 62% of students found that it was an interesting experience (Figure 9).
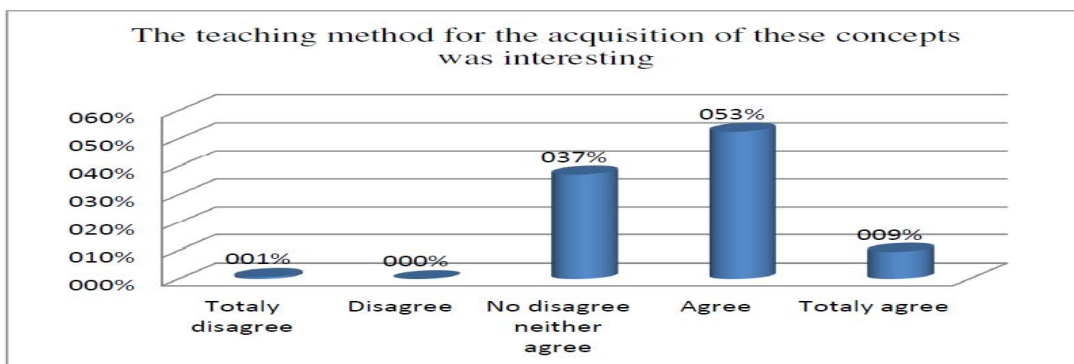

Figure 9: Interest in the Method of Teaching

The application of the PBL teaching method produced an overall positive motivational response, as can be seen in Figures 10 and 11. Indeed 66% of students expressed a preference for PBL teaching method.
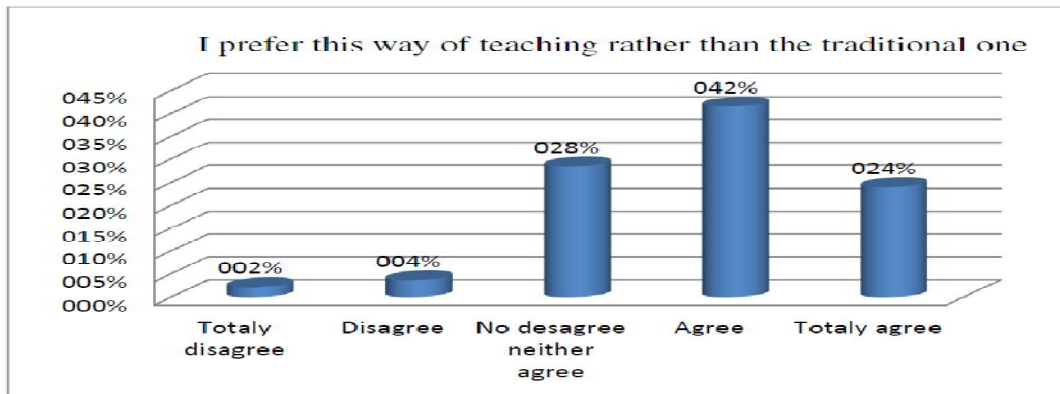
Figure 10: Preferably the Method of Teaching

Moreover, we observe in Figure 11 that 71% of reviewers recommend this method of teaching.
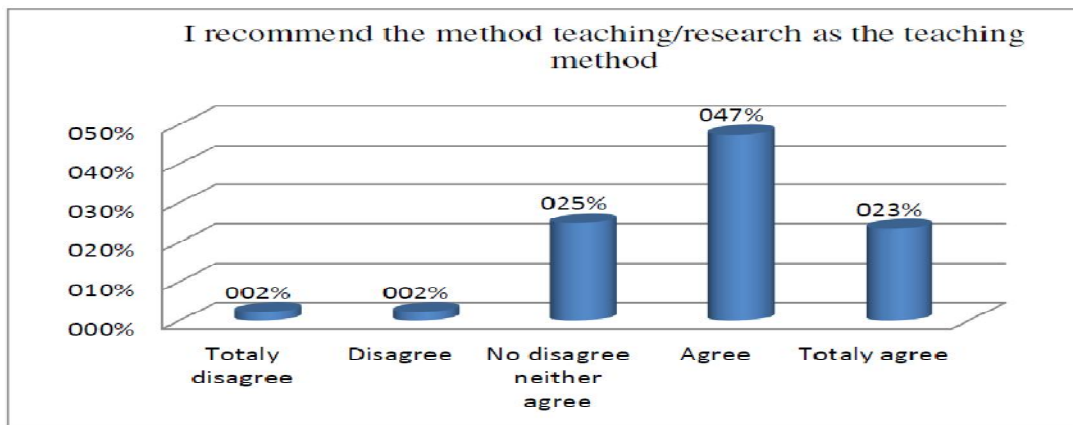

Figure 11: Recommendation as a Method of Teaching

Given the size of the sample collected, assuming independence existed between the responses, we can conclude that the percentage of students who support the PBL teaching method in the course of computer engineering ISEP is in the range [63%, 79%], considering a confidence level of 95%. This result encourages the application of this method to other content in the area of Statistics (eg, statistical control, inference, etc.).

4.2 Analysis of the Work

In this subsection, Figure12, we present an example and the resolution about the linear regression and linear correlation, made by the students.
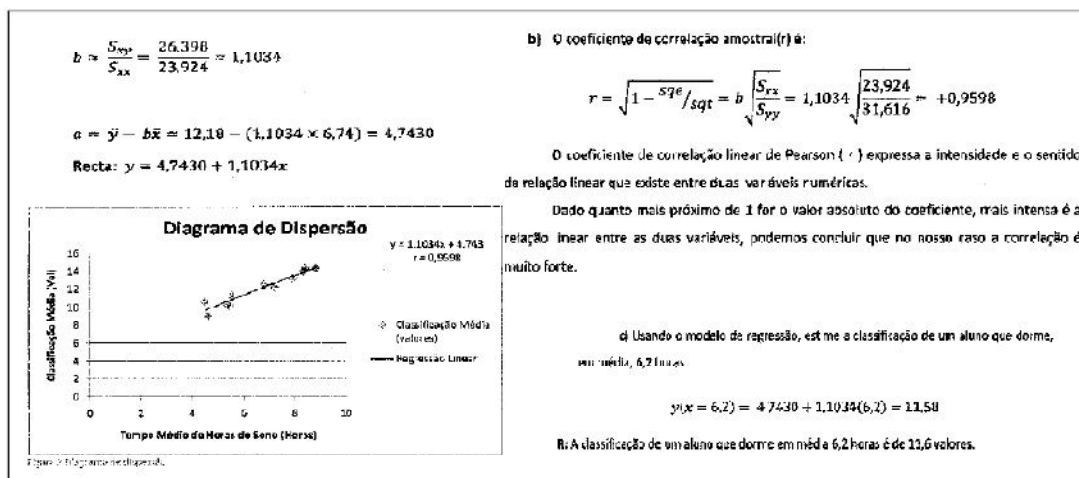
Figure 12: Student Resolution

The students answered correctly (in Portuguese) to the questions:

a) Represent the data in the diagram of dispersion. Assuming the model of simple regression is the appropriated one: Estimate the linear regression line and draw it on the chart.

b) Calculate the sample linear correlation coefficient r. Interpret this value.

c) Using the regression model estimates the classification of a student who sleeps on average, 6.2 hours.

5. Conclusions

The analysis of the works done by the groups, revealed that about 80% of the students have achieved the objectives proposed in the contents of linear regression and correlation. The six issues raised, performed by Mann-Whitney tests to enquire whether the responses were or were not influenced by the fact that some students weren't freshman in the course, reveal that the ones attended the course for the first time value significantly more the use of Excel to solve the problem.

For other items, the tests it's inconclusive when comparing both types of students. The analysis made to the questionnaire revealed that over 70% of the students appreciated the teaching/learning method that was proposed, and around 77% recognized that was Excel was a useful tool for them.

However, PBL, even in partial implementations of the present study, seems to be advantageous in comparison to expository instructional approach. Although the aggregation degree of certain unpredictability and the increase of the time dedicate, PBL seems to contribute enough to raise faculty satisfaction with teaching activities and encourage their professional development through the intellectual challenges posed by students. At least, that's what this research indicates, confirmed by the continued use of PBL in disciplines under the responsibility of the teacher/author. The overall rating of the teacher points out that the PBL method is a very good alternative teaching and learning. For the partial format adopted, of a discipline isolated in a traditional curriculum, it is still possible to contemplate the alternative of combine exposure lectures with work problems. This point of view from the teacher agrees with the overall assessment of students, around 90% of the students rate the implementation of the PBL as a positive learning (Escrivão Filho & Ribeiro, 2009).

The enhance of the student development was achieved as shown by the results in the analysis of the works. The improvement of the practice in the field of education was accomplished as shown in the results of questionnaire. The connections between research and practice were reached by some groups which used real data.

6. Limitations of the Study

This work had limitations naturally, concerning students and teachers both. As for the first ones they were: 1) used to "receive" all the information passively, students when placed in a situation that provides them with greater activity, work, initiative at the first moment present resistance to the new method, but slowly coming to blur over time; 2) more time is required to achieve the proposed the objectives of the work; 3) greater commitment and time are required in the elaboration of the texts since a large deal of creativity is required.

Regarding the second ones the limitations were: 1) greater commitment and time to elaborate the problems texts due to the creativity and the design of the problems; 2) leading the discussions with of the tutorial group, where the teachers need to be very well prepared; 3) implementation of the evaluative component, this way leading the more available time as possible of the students to dedicate to investigation new topics behind the scope of the course, which was an additional effort.

7. Applicability and Merits of the Work

Awake in the student the autonomy as a thinking being. Develops a critical spirit. Contributes to the development of a professional career and the individual training, namely sense of responsibility, capacity and disinhibition of organizing a working group, analysis and decision. More motivation, an increasing one for the students that are enrolled in this Curricular Unit of MATCP.

8. Future Work

Extend this method to other contents of the discipline. Make a comparison between the performances of the students in the various components taught in the areas with respect to the traditional one, were the contents were acquired according to the PBL method.

Conclude which one is the most appropriated to use in each chapter.

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