PBL AND B-LEARNING IN TRANSPORTATION EDUCATION

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ABSTRACT

The results of the application of a pedagogical strategy implemented at the University of São Paulo-São Carlos are presented and discussed in this work. The initiative was conducted in a transportation planning course offered to Civil Engineering students. The new approach is a combination of PBL (which in that case stands not only for Problem-Based Learning, but also for Project-Based Learning) and blended-learning. Distinct problems were considered in the period in which the method was applied (from 2006 to 2009), as follows: parking problems within the campus in 2006, general transport and mobility issues in the city in 2007, and mobility troubles for pedestrians in 2008. In 2009, the PBL concept was expanded to Project-Based instead of just Problem-Based Learning. The aim of the change was to allow the application of the theoretical concepts in a project for solving a real-world transportation problem. The performance of the students along the four years was analyzed through the grades they received in the course activities. We also analyzed the answers they provided in a questionnaire specifically designed for the course assessment. Both analyses provided important elements for the improvement of the pedagogical approach. Also, the results of the experience with the four classes showed positive aspects of the method, such as a strong involvement of several students with the subject, in addition to a very mature and professional attitude when dealing with the proposed problems. That already resulted in a growing interest in the field of transportation engineering for further studies.

1. INTRODUCTION

In most Civil Engineering colleges in Brazil, a rigid curriculum makes it difficult the immediate inclusion of emergent techniques and the development of the new skills demanded by the market. In order to meet these market needs, the School of Engineering of São Carlos at the University of São Paulo (EESC-USP) is introducing changes in some of its courses. The goal of these changes is to produce professionals with a strong ability of adaptation to the dynamic movements and needs of the market. This is done while keeping the education standards based on solid theoretical foundations and on good practices in Engineering, what has been a tradition at EESC-USP for more than 50 years.

The aforementioned goal can be reached with a constant improvement of the teaching-learning process. It can be done, for example, through innovative pedagogical approaches eventually supported by Information and Communication Technologies (ICT). This paper discusses one such pedagogical alternative that is applied to the course "*Transport Systems Planning and Analysis*". At EESC-USP, that course is designed for Civil Engineering students enrolled in the sixth semester (out of ten). The proposed approach associates Problem-Based Learning (PBL) with a Learning Management System (LMS), as described in (*1*) and (*2*). The course deals with concepts related to economic and social aspects of transport systems and their influence on transport planning and operation.

PBL was first introduced in the course in 2006 with an issue that most students were familiar with: parking problems in the Campus area. In the next year, the focus was on the major transport problems of São Carlos, which is the Brazilian medium-sized city where EESC-USP is located. In that particular case, the students relied on the results of a field survey just finished by the Department of Transportation of EESC-USP. In 2008, the students dealt with the mobility problems faced by pedestrians also in São Carlos. They had to take into account the accessibility levels of urban spaces and the quality of the pedestrians' infrastructures available in the city. Therefore, from 2006 until 2008, the approach was essentially centered on the diagnosis of the problems and only superficially on projects with solutions. In 2009, concepts of Project-Based Learning were added to the methodology and the final course project became a more detailed product offering solutions to a transport problem. In that case, the students had to design an alternative solution to the existing urban public transportation system. In order to do so, they were granted access to the data of an origin-destination survey recently finalized in the city also by the Department of Transportation of EESC-USP. In all four years, teamwork was a strong feature of the approach, which also relied on the LMS named CoL (it stands for Courses on-Line). This LMS developed at the Polytechnic School of the University of São Paulo incorporates dynamic tools to stimulate interaction between the instructor and the students and among the students themselves.

The objective of this work is to present and discuss the results of the pedagogical strategy combining PBL with b-learning (or blended learning) that was implemented in one course at EESC-USP starting in 2006. In addition to this introduction, this document brings a short review of the background that is needed for understanding the approach, and the methodology for data acquisition and analyses regarding both the students' performance and the course assessment. The results of the analyses are presented in discussed in section 4, what provides the elements to draw the conclusions presented in section 5.

2. BACKGROUND

In order to facilitate the comprehension of the experience discussed in this paper, it is necessary to look at what has been done at EESC-USP for improving the transportation engineering courses at least along the latest fourteen years. It is also necessary to briefly review some basic aspects of PBL, such as its definition and suitability to the case under consideration. The characteristics of blended-learning are also discussed in this section.

2.1. Transportation Engineering Education at EESC-USP

The main innovations introduced in the courses in the field of transportation at EESC-USP can be found in Kuri *et al.* (*1*). In summary, in the period of time starting in 1996 and reasonably well documented until 2003 (*3*, *4*, *5*, *6*, and *7*), the main concern was to incorporate the analytical resources of the technological developments and of emergent techniques (such as Geographical Information Systems, for example) to the existing courses framework. In fact, the goal of updating the contents of the courses with the new analyses tools still remained, but after 2003 there was also a concern to adapt the proposals of pedagogical changes to the personality types and learning styles of the Civil Engineering students. That was strongly influenced by the work of Kuri (*8*) and the developments were later discussed in (*9, 10, 11*, and *12*). Despite the several variations aiming at the improvement of the teaching-learning process, these studies never considered the introduction of PBL. This was the motivation for the experience now discussed.

2.2. PBL

The main difference between the 'traditional' approach and PBL resides in the fact that the later tries to assure that students understand the facts, instead of simply memorizing concepts, descriptions or formulas (more about it can be found in *13*, *14*, and *15*). In addition, as the method is strongly based in teamwork, the students have to develop cooperative work and interpersonal relationship skills. These are undoubtedly positive features for the future professionals under development. The approach has advantages to the instructors as well, given that quite often they also learn along the course, although the process is a complex and continuous challenge.

Just like any other approach, PBL is also subject to problems and criticisms, as it can be found in (*16*). In addition, although education in engineering can, in general, benefit from PBL, the adaptations needed are quite often not easy (as discussed in *17* and *18*). The case of Transportation Engineering is not different, but it is already possible to find, in a simple internet search, several universities that apply PBL in transportation-related courses. They may be located in quite distant countries, such as Malaysia, United States, and Spain. In Brazil, however, it is not easy to find records of similar experiences. It makes the present pedagogical initiative in transportation engineering particularly timely and relevant for the country and for other places where the concept is also not yet consolidated. Even in countries were the approach is found in practice applied to transportation education, reports of the experiences are not very common (one exception is found in *19*),

2.3 Blended Learning

Computers have been traditionally applied as tools for processing and transferring information and as decision support elements. They assumed a new dimension when started to be intensively used for education, training and personal development. Despite the potential of the new technological tools, some education researchers who are deeply interested in facilitating the teaching-learning process realized that neither on-line platforms nor pure theoretical approaches

about the teaching-learning process can independently produce a scenario of effective learning. A strategy to overcome that limitation is to combine informatics resources with the traditional classroom approach, in what is now called blended-learning (or b-learning). So, b-learning can be simply described as an integration of the face-to-face classroom-like teaching-learning process with on-line experiences of distance education. A research-based class can then be developed in that sort of environment. In essence, the role played by the instructor is to motivate the students while showing them the value of the topics to be learned, as well as the importance of the process. Motivation and active participation are key elements in the development of the apprentices. More about blended learning can be found in (*20* and *21*).

After an initial verbal and audiovisual presentation for stimulating the interest of the students, they can start searching, individually or in groups, for more information about the suggested topic. Useful sources can be the World Wide Web, books, and contact with actual experiences or professionals dealing with the subject. A selection of the best contents found by the students and by the instructor must be made available to everyone. Those outcomes are then brought back to the classroom, where the colleagues and the instructor can help in setting up the context in which the results fit in. That helps to widen the views reached so far, to identify the problems, and to find new meanings in the information gathered. The back and forth movements, in which everyone is invited to participate and to get involved with, is fascinating, creative, and full of discoveries and progresses. The knowledge built on self experiences then becomes stronger.

Part of the success of any b-learning initiative depends on the technology available for the part of the course conducted at a distance. Learning Management Systems can play an important role in that case, because they provide dynamic tools for promoting interaction between instructors and students through forums, electronic communication (i. e., mail and chats), and collaborative activities. Therefore, it can be useful for both distance learning and b-learning.

3. METHODOLOGY

This study focus on the analysis of the results of four sequential experiences with a pedagogical alternative developed at EESC-USP for teaching transportation planning for Civil Engineering undergraduate students. The approach consists in the combination of PBL techniques with a Learning Management System, as listed below (and also summarized in Table 1):

i. Introduction of PBL as the selected teaching-learning approach, with a strong focus on teamwork.
ii. Intense use of a Learning Management System (in this case, the platform CoL).
iii. Adoption of a b-learning strategy to combine topics (i) and (ii) above.
iv. Complementation of the traditional methods applied in the discipline with the following strategies:
- Teamwork;
- Individual and group research in the World Wide Web;
- Use of a computer laboratory for part of the course activities;
- Use of Geographic Information Systems for developing the project activities.

v. Use of quizzes, exams, transcripts of the students, access information recorded by the LMS, and performance of the students throughout the semester as data for evaluation and monitoring the pedagogical proposal.
vi. Evaluation of the results by means of quantitative and qualitative methods.

The goal of the approach is not only to produce significant improvements in the learning process, but also to positively affect the attitude of the future professionals. The implementation of the innovations is gradual but constant. That allows the identification of problems in periodical evaluations and the correction of any flaws detected, as discussed in (*2*).

The evaluation of the experience outcomes is an important part of the pedagogical strategy. Two aspects are considered in our case. The analysis of the students` performance records and of the results found in a questionnaire designed for course assessment.

TABLE 1 Summary of the approach developed for combining PBL and b-learning at EESC-USP

1. PROBLEM STATEMENT		
Environment	**Description of activities**	**Persons involved**
Classroom	Introduction of the problem. Regarding the problems selected for the practical part of the course, we tried to focus on ill-structured problems, which are not rare in the transportation planning field. That was not exactly the case of the 2006 problem, which was about parking facilities within the university campus. In the following years, though, that characteristic was increasingly observed when defining the problems. General transport and mobility issues in the city were considered in 2007, and mobility troubles for pedestrians in 2008. In 2009, the students had to design an alternative solution to the existing public transportation system in the city.	Instructor
	Presentation of alternatives for solving the problem.	Students
2. FORUM I		
Environment	**Description of activities**	**Persons involved**
LMS	Discussions about the problem introduced in step 1, about the alternatives for solving it, and suggestions on how the selected alternatives could be implemented.	Students
	Evaluation and selection of two contributions from the list of solutions generated with the discussion above.	
	Selection of the best alternatives for data collection.	Instructor Teaching Assistant (TA)
3. PRACTICAL ACTIVITY I **ASSIGNMENT I - DATA COLLECTION**		
Environment	**Description of activities**	**Persons involved**
Instructor's office	Division of the class in groups, based on the students` personality types and learning styles found with the application of specific tests.	Instructor Pedagogue
Out of the classroom	Selection of group leaders.	Students
	Assignment of the activities to be developed by group members.	Leaders
Field	Data collection.	Groups

TABLE 1 (cont.) Summary of the approach developed for combining PBL and b-learning at EESC-USP

4. PRACTICAL ACTIVITY I ASSIGNMENT II - DIAGNOSIS AND DEVELOPMENT		
Environment	**Description of activities**	**Persons involved**
Computer Lab	Two elements of each group are trained on how to use a GIS-T package.	TA
LMS	Application of tests to check the GIS-T skills of the students.	TA
LMS	Preparation and online publication of a descriptive report with a diagnosis of the problem under analysis. It is strongly recommended to use GIS in the preparation of the report.	Group
5. FORUM II		
Environment	**Description of activities**	**Persons involved**
LMS	Comparison of the outcomes presented in the reports of Practical Activity I with the discussions posted in Forum I. Discussion about strategies on how to implement the alternatives selected in step 2 and worked in steps 3 and 4.	Students
6. PRACTICAL ACTIVITY II FORMULATION AND PRESENTATION OF THE RESULTS		
Environment	**Description of activities**	**Persons involved**
Out of the classroom	Preparation of a final report containing the following elements of the selected project alternative: introduction and justification, sketches of the design solutions, implementation steps through time, and cost estimates.	Group
LMS	Online publication of the final report.	Group
Classroom	Oral presentation of the final report using *MS PowerPoint* or a similar package.	Group
Classroom	Evaluation of the individual contributions of the students to the respective groups. This is done in the classroom, together with one of the exams, when all students are asked to report the contributions of all group members (including him or herself) to the final work.	Instructor TA
Instructor's office	Analysis of the answers to find out the individual commitment of the students to the proposed activities.	Instructor TA
7. EVALUATION OF THE PEDAGOGICAL PROPOSAL		
Environment	**Description of activities**	**Persons involved**
Instructor's office	Development of a questionnaire designed for course assessment, with twenty questions. Ten questions are related to the new approach, six related to the evaluation processes and four related to the LMS.	Instructor TA Pedagogue
LMS	Questionnaire application.	Students
Instructor's office	Analyses of the questionnaire answers.	Instructor TA

4. RESULTS

In this section we discuss some of the main results found in the records of students` performance and the outcomes of the assessment questionnaire.

4.1. Students' Performance

Some of the main indicators of students' performance found from 2006 to 2009 regarding the activities 2 to 6 (see Table 1) are displayed in Table 2. While activities 2 and 5 (*Forums I* and *II*, respectively) were individual contributions, all other activities involved teamwork. As activities 3 and 4 were graded together, the values displayed under the label '*PBL*' in Table 2 summarized

the assessment of four activities (2, 3-4, 5, and 6), in a scale from zero to ten. The other information displayed in Table 2 refers to the 'traditional' classroom activities also conducted in the course, such as quizzes and exams. The values presented in Table 2 suggest an improvement in the students' performance in the PBL activities throughout time. The same cannot be said about the quizzes and exams, for which no clear pattern can be devised.

The distribution of grades in the PBL activities can be seen in Figure 1. Again, activities 2 and 3 of Table 1 are presented as a single value, under the denomination *Practical Activity 1*. In the case of PBL, the increase in the average is a direct consequence of an increase in the number of students with high grades. In 2006, only one student got the maximum grade and the overall performance of the group was good, but seven students were below 50 % of the maximum. In 2007, no student reached the maximum grade, but ten students got grades eight or higher. Also, the graph in Figure 1 shows that the standard deviation reduction confirms a more uniform performance in 2007 than in the previous year. Two students reached the maximum grades in 2008, while twelve other were above the 80 % threshold. The introduction of the project-based approach in 2009 produced an even more positive change in the students' performance: 22 % of the thirty enrolled students got grades eight or higher (although no one reached the maximum possible value).

TABLE 2 Students' performance in the course activities from 2006 to 2009

Year	PBL		Quizzes *		Exams **	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
2006	6.77	2.34	6.35	1.19	6.38	1.63
2007	7.12	1.57	7.22	1.41	5.64	1.57
2008	7.54	2.00	6.29	1.59	5.22	1.56
2009	8.24	1.43	7.10	1.59	6.66	1.76

* The students have four quizzes during the semester, but only the three best results are usually considered in the calculation of the average.

** The students have three exams during the semester, but only the two best results are usually considered in the calculation of the average.

4.2. Course Assessment

In this section we discuss the results of a course assessment questionnaire addressing the proposed PBL approach. Twenty questions were answered online by all students immediately after the end of each course edition. Ten questions refer to the method applied, six questions to several aspects of the course, and four questions are about the LMS. The results of the first sixteen questions are grouped under common topics in Figures 2 to 5 to facilitate their analyses. The questions about the LMS are not discussed in this paper, due to their technical nature.

The results of Figure 2 show that the classes of 2006 and 2009 were the ones with the highest approval rates, with the answers 'Very Good' and 'Good' summing up 77 % of the total. Even the worst year, however, showed a sum of 64 % for these two alternatives, what is also a good overall evaluation. A direct comparison of the 2006 and 2009 results favors the former, since 2009 reports one 'Very Poor'' answer for the first time in all four years.

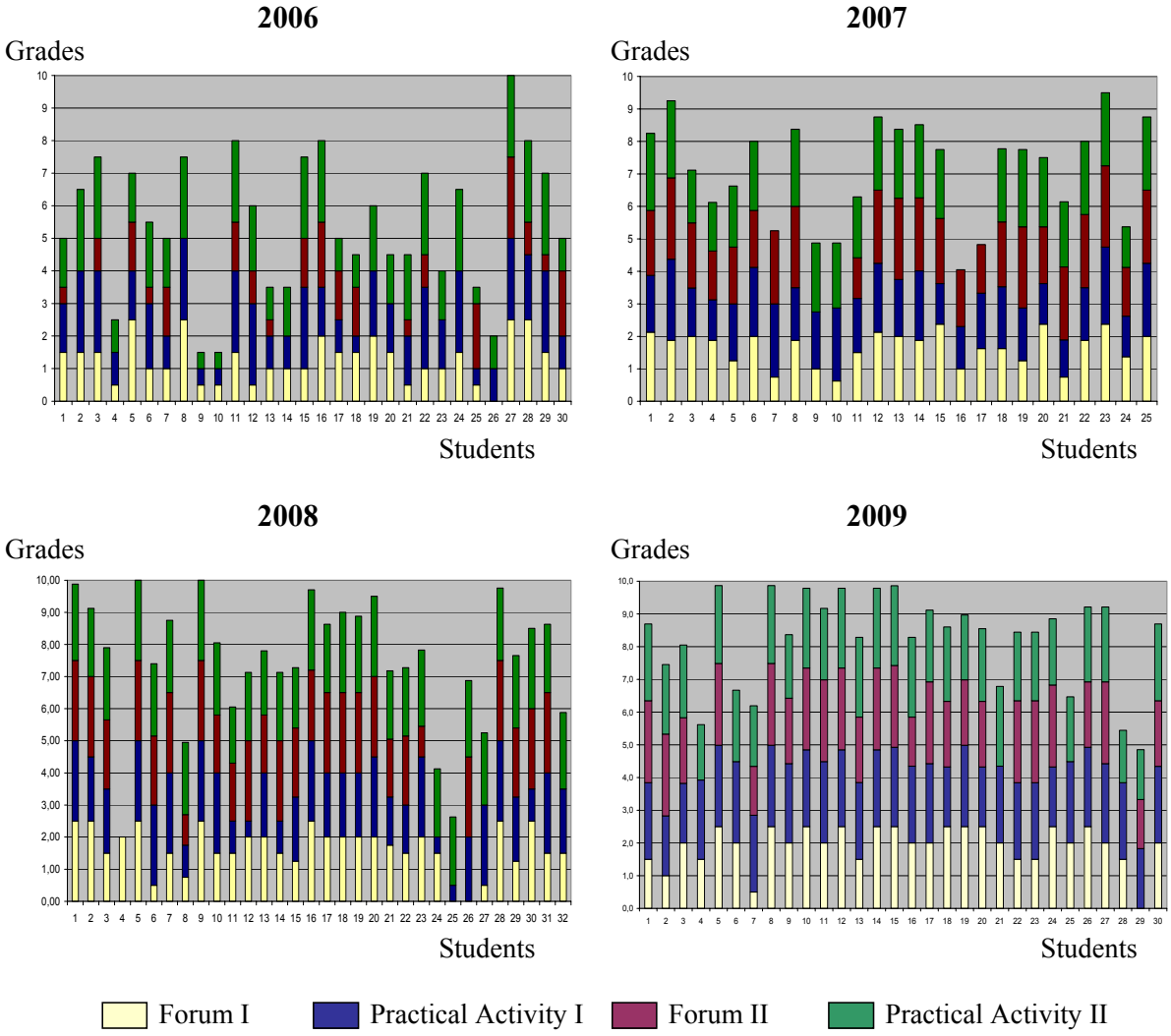

FIGURE 1 Students' performance in the main PBL activities from 2006 to 2009.

The question referring to the coherence between the course contents and what was asked by the instructor to the students shows a reduction in the approval rate from 2006 (89 % of 'Strongly Agree' and 'Agree' answers) to 84 % in 2007 and 69 % in 2008. Again, even the lowest value is still not bad. In addition, the percentage of 'Disagree' was always very low (0 % in 2006 and 2009, 4 % in 2007, and only 7 % in 2008. The alternative 'Strongly Disagree' was never selected. That result is a consequence of the actions taken by the instructor to improve an aspect that led to the reduction in the acceptance rates, even considering that the level of dissatisfaction was never too high. The question in which the students manifested their opinion about the time required by the course activities, in comparison to other courses, has shown some variation along the four years. This is probably a consequence of the kind of problem they were dealing with, which was always different from year to year.

It is important to mention that the topic considered in 2007 (*Transport and mobility problems in the city of São Carlos*) had the advantage of relying on an existing survey, which the students had only to introduce in a computer database, and further analyze the data. In that

particular case, as the data was generated thanks to a funded research, the teams of students that inserted more than a minimum number of questionnaires in the database received a payment for their work. In fact, all teams did more than the minimum and therefore they all got paid for the additional job. That might be the reason why the options 'Strongly Agree' and 'Agree' had a reduction in 2007. They spent some extra time for doing the activities, but they did not see it as a burden because of the payment associated to it. In the years 2006 and 2008, alternatively, they had to perform some field work for data collection, what certainly required more time than the typing activities of 2007. In 2009, the introduction of the project-based learning concepts represented a bigger challenge to the students. The activities became more complex and singular. Among other things, it significantly reduced the possibility of copies among groups.

The results regarding the level of exigency of the PBL activities showed a slight increase, from 2007 to 2009, in the proportion of students who considered the course more demanding than most courses following the 'traditional' approach. However, the percentage of students who answered that the PBL activities required a time equal to or smaller than a traditional course changed from 69 % in 2006 to 76 % in 2007, then moved back to 69 % in 2008, and finally 63 % in 2009. In general, the small variation of the results in the questions referring to the pedagogical approach (Figure 2) indicated a positive trend.

The results shown in Figure 3 refer to the preferred interaction means, how comfortable the students felt during the group activities, the activities that contributed the most to the learning process, and how they evaluate the project activities.

A good result is the one showing an increase in the proportion of students who marked 'Group Activities' as the preferred interaction mode. That answer is particularly positive because it is in line with one of the goals of the pedagogical approach, which is to learn how to interact in teams. That helps to develop an attitude of mutual cooperation and respect of different opinions. The alternative 'Group Activities' started with only 18 % in 2006, but reached 50 % in 2008. The reduction observed in 2009 was not so expressive, since the value observed (40 %) was the second highest. It is interesting to observe the regularity in the proportion of answers pointing 'Individual interaction' as the preferred option, almost always around 30 %. A reduction in the percentages of the option 'Forum' was observed from 2007 on. That reduction may be explained by the increase in the preferences of the alternatives 'Group Activities' and 'Individual Interaction', and not necessarily because the students dislike the discussion activities or that they became meaningless.

The results showing how comfortable the students felt while working in groups reinforced what was observed in the previous question. The proportion of students stating that they `Always` felt comfortable with teamwork increased from 38 % in 2006 to 64 % in 2007, and to 72 % in 2008. The value decreased to 60 % in 2009, but fortunately that decrease did not represent an increase in the alternative 'Rarely', which remained with 7 % of the answers (in 2008 and 2009).

Regarding the activities that contributed more effectively to the learning process, the preference was consistently the same along the four years: 'Classroom Exercises'. The percentages grew from 51 % and 52 % in 2006 and 2007, respectively, to 58 % in 2008 and 67 % in 2009. A possible explanation for that preference can be the fact that the Exams and Quizzes were always based on subjects viewed in the classroom and never on topics of the Forums or Group Activities. The other alternatives in the same question (i. e., 'Forums', 'Group Activities', 'Exams', and 'Quizzes') had percentages between 3 and 16 %, with no clear pattern observed along the years.

The question asking about the 'Project Activities' had a positive change from 2006 to 2009, which was visible in the growing proportion of the alternatives 'Excellent' and 'Good'

altogether. The value of 2009 (90 % for 'Excellent' and 'Good' combined) is particularly interesting, because that was the year when the project activity has gained a very strong emphasis, thanks to the adoption of a project-based oriented approach. The 2009 results are even more significant if we examine the percentage of 'Excellent' (33 %), which has more than doubled in relation to 2007, when it was 16 %, and tripled in relation to the 11 % of 2006. This can indicate a tendency of the students to get motivated with complex challenges clearly connected with real-world professional activities, which is one of the ground stones of project-based learning.

Figure 4 summarizes, in the first two graphs, the results obtained in the questions that asked for a comparison of the traditional and proposed approaches. The other two graphs refer to questions used to asses the role of the instructor and the quality of the course contents.

A somehow negative outcome was observed in the first question of the group, in which the added percentages of students who selected the options 'Strongly agree' or "Agree' has been around one third of the total from 2007 to 2009. Also, the students who disagreed were never more then 42 % (in 2006). That reaction of the students towards the new approach can probably be explained by the fact that most courses taught at EESC-USP follow a 'traditional' approach. Therefore, the students are neither used nor comfortable with changes in the way they are supposed to learn. The results found so far, however, can be incorrect. That assumption is based on a question addressed to the TA by one of the students in 2009. She understood the question all the way around, what means that disagree and agree might also have been used in an inadequate manner by some of the students. That certainly demands a change in the question in the future, in order to avoid the confusion.

An indication that the results of the first question of Figure 4 are indeed confuse comes from the results of the second question in the group. When asked if they would like to follow another course with the same format, the proportions of 'Yes' (76 to 85 %) were significantly higher than the proportion of 'No` (15 to 24 %) along the four years. It seems to indicate a strong and favorable trend towards the new pedagogical approach, what was not so evident in the previous question. The differences in the two questions may indicate two things. First of all, that there was really a problem in the previous question. Therefore, the answers are not reliable and should not be taken into account. Conversely, if the problems in the previous question were not so serious, then we can assume the results are correct. In this case, they suggest that students are open-minded in relation to the new approach, although they are not used to it and not necessarily confident about it.

In the third question of Figure 4 the students were supposed to declare if the instructor stimulated their critical reasoning. Although we observed a reduction in the percentage of 'Strongly Agree' after 2006, the combined percentages of 'Strongly Agree' and 'Agree' remained all four years around 80 %. In addition, just a few students had a negative view about it in 2006 and 2008, while the rest was 'Neutral'.

Regarding the course contents (forth graph of Figure 4), a very large proportion of students saw them as both interesting and useful. In addition, the remaining students found them either interesting or useful. No student during the four years declared that the contents were neither interesting nor useful.

The results presented in Figure 5 refer more specifically to the learning process. In general, they were very positive in relation to the course and also to the project (graphs a and b of Figure 5), what seems to indicate a consolidation of our pedagogical approach. Although the question regarding the performance of the students in the project (Figure 5b) still had a large proportion of positive answers ('Very Good' and 'Good') in 2009, the combined value (57 %) is

smaller than the values of the other three years. It has also interrupted a growing trend. The increase in the proportion of the 'Fair' (to 33 %) and 'Poor' (to 10 %) alternatives can be a consequence of the changes introduced with the project-based approach. However, the openness of the 2009 class in the self-evaluation is undoubtedly a positive aspect of the assessment results.

The results of the overall course evaluation were also very positive, with 97 % of the answers 'Good' and 'Very Good' in 2009. The other 3 % were not bad at all, as they were answers marked with the 'Fair' alternative. This is the best result of the four years with the new methodology, with a noticeable increase in relation to the other three previous years. As the only significant change was the project-oriented approach, we associate the even better overall course evaluation in 2009 to it.

Finally, we observed a very positive result also in relation to the learning evaluation in 2009, when 37 % of the students declared that their learning was better than it would have been in a `traditional' course setting. That is a 9 % increase (from 28 % to 37 %) in relation to 2007 and 2008, and even higher in relation to 2006.

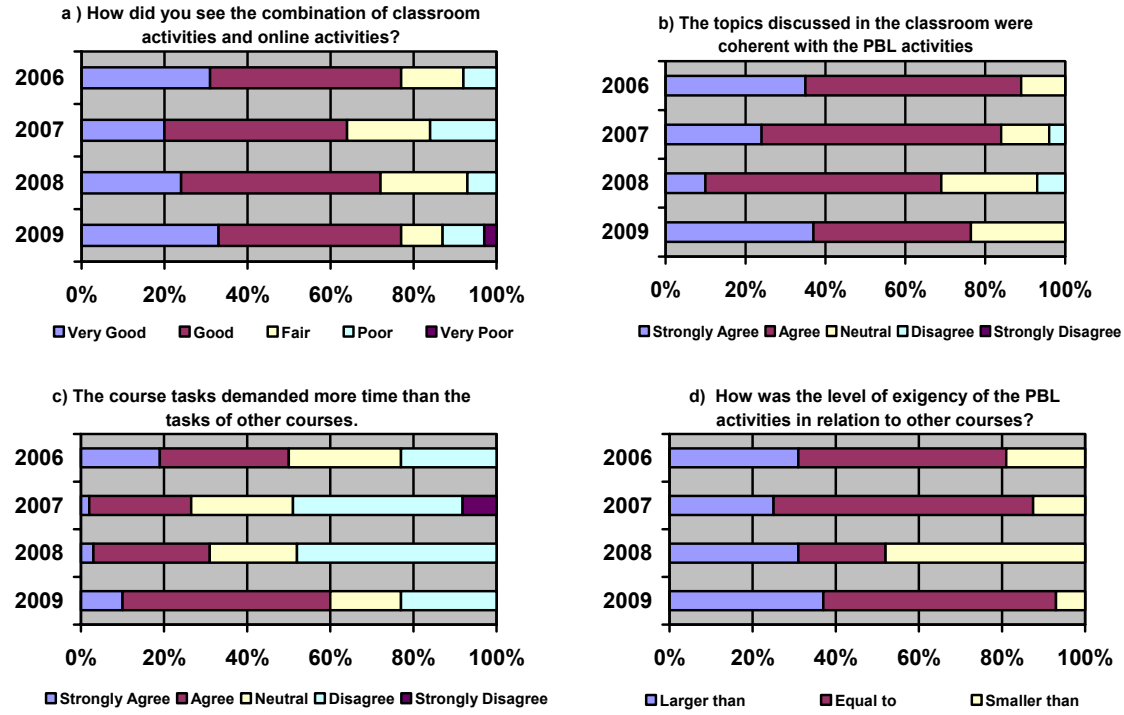

FIGURE 2 Distribution of the answers to the questions regarding the course proposal.

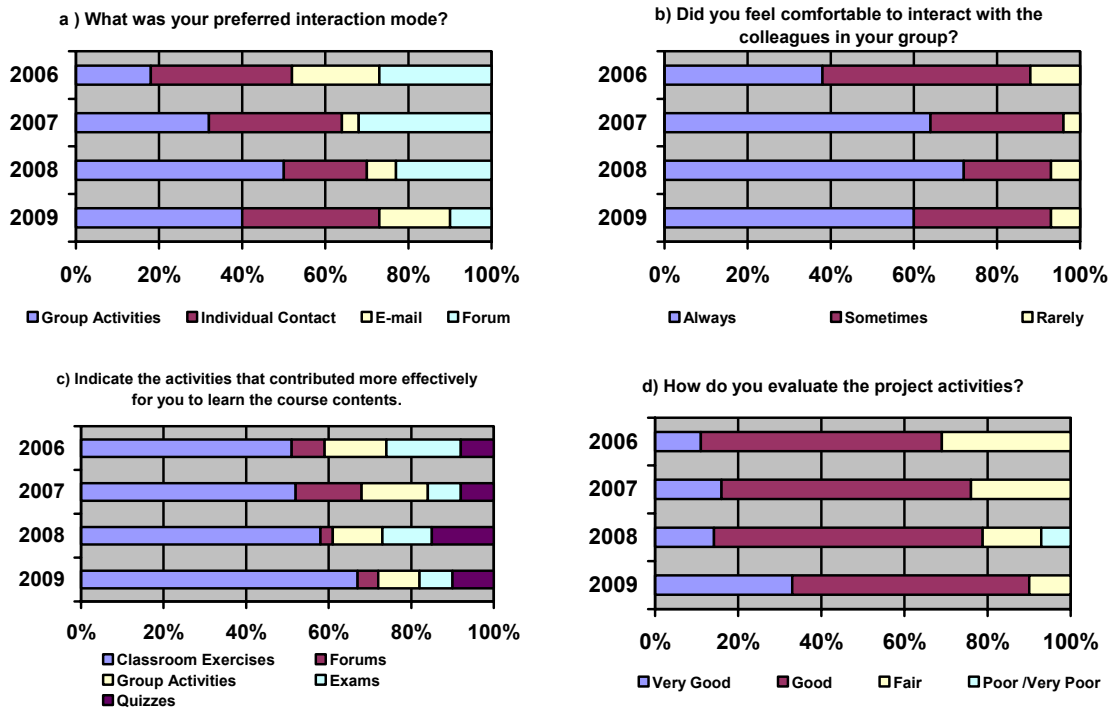

FIGURE 3 Distribution of the answers to the questions related to the PBL activities.

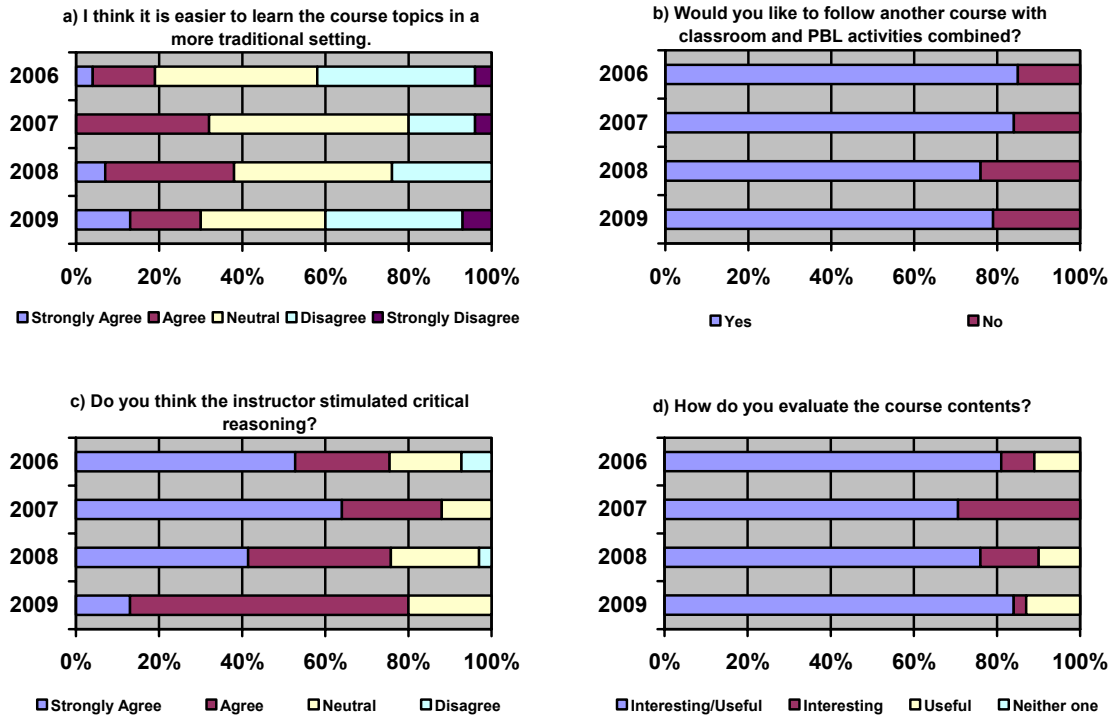

FIGURE 4 Distribution of the answers to the questions regarding the potential of the proposed approach in comparison to the `traditional` one.

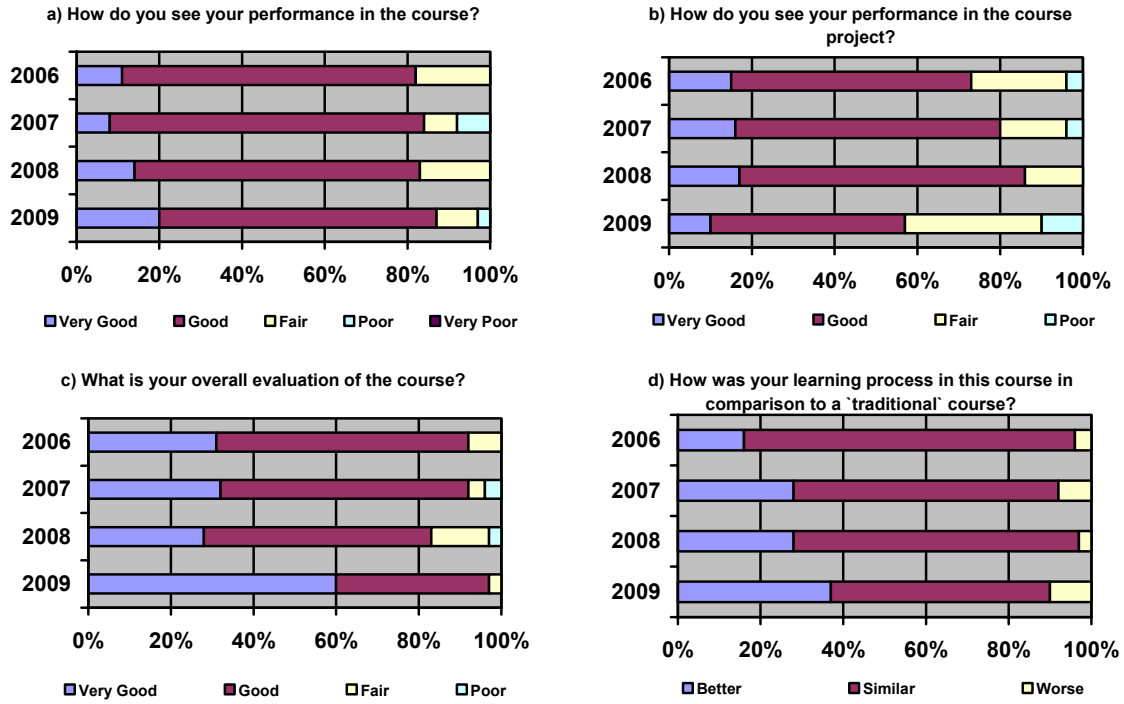

FIGURE 5 Distribution of the answers to the questions related to the learning process.

5. CONCLUSIONS

The pedagogical strategy combining PBL and b-learning in a transportation planning course at EESC-USP started back in 2006 aiming at the improvement of the teaching-learning process in transportation engineering education. A comparative evaluation of the proposed approach during the four years of application was carried out for this study in two ways: *i*) through an online questionnaire regarding the course itself, the PBL activities, and the LMS used; and *ii*) by looking at the students' performance on the various course activities. The results showed an improvement in nearly all aspects assessed and a gradual consolidation of the proposed approach.

A careful examination of the results obtained in each course edition and the immediate actions taken to adjust the problematic aspects were very important to assure the improvement process along the four years. This can be drawn from an analysis of the complete set of answers provided by the students from 2006 to 2009. The overall acceptance of the proposal had a small drawback in 2008, but an expressive recovery in the following year. In 2009, the Problem-Based Learning strategy was adapted to further incorporate concepts of Project-Based approach. The interest demonstrated by the students for the actual problem proposed for them to deal with was visible in the classroom lectures and also in the computer lab activities.

That perception was confirmed by the evaluation of the students regarding the PBL activities, which were better in 2009 than in the three previous years, despite the increase in the amount of theoretical concepts required in the latest year. In addition, the proportion of students willing to take another course with a similar format, if offered at the University, grew once again from 2008 to 2009.

The new course design has also allowed the confirmation of the students' excellent performance on their final oral presentations. They were a result of research and commitment to

work that most likely would not be found in a traditional teaching-learning setting. Also, with regard to the course project, there was a strong commitment of the teams with the quality of the solutions produced. They were orally defended with a very professional attitude, what is certainly a positive feature for third-year students, who are already preparing themselves to a reality they will have to face two years ahead, after graduating.

The purpose of this paper was to provide insights for transportation educators by showing some of the positive and negative aspects that can appear in initiatives like the one we discussed here. Unfortunately, we did not have the opportunity to discuss some other important aspects, such as the roles of facilitators instead of instructors/lecturers, the syllabus and the assignments used in this course, and the limitations of the approach. Also, we were not able to confirm the success of this program if compared to a more conventional approach, or even to the conventional course that preceded this new approach. At least in the first case we have successfully done that comparison by using cognitive maps, but the results are reported elsewhere (22).

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