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Problem–Based Learning in an Online
Comparative Education Graduate Course

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Abstract

The case study that is addressed in this paper is the result of an experience using problem–based learning (PBL) in an online Comparative Education course offered to students from Mexico and Latin America. This study focuses on peer interaction, on the way in which PBL promoted this interaction, and on the degree to which all this, in turn, promoted collaborative learning. The results and the discussion were organized around four major topics: (1) Threads of thought generated in electronic forums; (2) the efficient use of the electronic forums in the study of the problem; (3) the level of mastery of the PBL technique accomplished by students in an online course; and (4) the effectiveness of PBL for fostering collaborative learning.

INTRODUCTION

In the last five years, we have been witnessing a rapid development of information and communication technologies, as well as the use of distance education via Internet. Statistical information on these trends

is abundant. As an example, the International Data Corporation (IDC) estimates that by 2003, the number of Internet users world–wide, which was 87 million in 1997, will grow to about 508 million (Smith, 2000). With respect to U.S. distance education, the IDC also estimates that the number of students in this modality will increase at a compound annual growth rate of 33% in 1999–2004, with enrollment expected to reach 2.23 million in 2004 (IDC, 2000). Moreover, the e–learning market for higher education could reach $2.2 billion dollars by 2004 (IDC, 2001). Finally, it is predicted that the number of U.S. colleges offering distance learning will increase from 47% in 2000 to almost 90% by the end of 2004 (IDC, 2001). As these figures show, a tremendous amount of resources are being invested in distance education programs.

In this not–so–new education modality, however, we are also witnessing a tremendous heterogeneity of the market offer. At a press conference on April 4, 2001, for example, the Massachusetts Institute of Technology (MIT) announced its commitment to make the materials from nearly all of its 2,000 courses available on the World Wide Web for non–commercial use (MIT, n.d.). This availability of academic materials does not necessarily imply that they will be available in well designed online courses. Among the huge variety of online courses, we can find notable differences in their design, in their use of teaching and learning strategies, and in the degree and quality of interaction among students or among professors with their students.

Among countless factors that may contribute to a successful course, perhaps one of the most important is the interaction among teachers and students. On September 16, 2001, the Washington Post Magazine published the following:

> Many universities that made sizable investments in e–learning programs are discovering that the concept has yet to live up to its hype... Whereas top universities with for–profit efforts are offering courses taught by star faculty and enhanced by flashy, costly technology, nonprofit schools are doing well because they offer a high degree of interactivity between teachers and students. (Shea, 2001)

This remark precisely underlines the importance of instructor–students interaction. However, this is just one kind of interaction that is present in online courses. Another crucial form of interaction is what

we call peer interaction—the communication that takes place among the students.

Given the fact that adult learners have a broad experience to share with their classmates, peer interaction plays an important role. Adult students' experience is a relevant feature in any educational process and therefore should be promoted in any instructional design. If peer interaction is acknowledged as a relevant form to construct knowledge, it is then important to identify some teaching and learning techniques that may help to promote it in a systematic way. It is here where problem–based learning (PBL) techniques enter into play.

The PBL technique can be characterized as follows:

> A collection of carefully constructed problems is presented to small groups of students. The problem usually consists of descriptions of sets of observable phenomena or events that need explanation... The task of the student group is to discuss these problems and produce tentative explanations for the phenomena, describing each in terms of some underlying process, principle, or mechanism. (Norman & Schmidt, 1992, p. 557)

It is important to note that although PBL was originally developed in the context of the health professions, it has been widely used in many other academic disciplines. Additionally, PBL has been very useful in face–to–face settings, in which traditional modes of communication are changed with the goal of promoting small–group interaction. However, the use of PBL in virtual learning environments is at its outset and only recently are some educational institutions implementing the technique in their online courses.

The case study that is addressed in this paper is the result of an experience using PBL in an online course. A case study, according to a popular definition, is "an intensive, holistic description and analysis of a single entity, phenomenon, or social unit" (Merriam, 1988, p. 16), thus the authors believe that keeping an intensive, holistic account of what happened in this course is worth doing to understand the intricacies of the technique. Our goal then is to provide some insight on the failures and successes of implementing PBL in a virtual classroom. In particular, this paper focuses on peer interaction, on the way in

which PBL helped this interaction, and on the degree to which all of this, in turn, promoted collaborative learning.

Institutional Contextual Framework

With its own unique features, "[a] case is a complex entity operating within a number of contexts—physical, economic, ethical, aesthetic, and so on" (Stake, 2000, pp. 439–440). Therefore, in order to understand the nature of a case, it is important to place it within a more general context and, little by little, to advance towards the target themes. Since in this paper our target theme is the study of peer interaction in an online course, we will pursue this target by describing three contextual frameworks. From the general to the specific, they are: The educational institution in which the course was offered, the course itself in which the interaction took place, and the way in which PBL was implemented within that course.

The case that we are going to discuss was developed in the Universidad Virtual [Virtual University (VU)] of a large multicampus educational institution in Mexico, the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM). The VU is a part of an ambitious institutional plan which, in the words of its former president, has the intention of offering "[distance] education through innovative educational models and the most advanced technology in order to support the development of Mexico and Latin America" (Cruz, 2001, p. 187). The VU is a university within another university system, with an international "flavor" and with the ambitious mission of bringing graduate programs to locations in Mexico with scarce or no educational offer. Little by little, the VU gained new markets inside and abroad, and it was instrumental in ITESM internationalization goals in Latin American. At present, the VU has in place a strong technological infrastructure for TV broadcasting, videoconferencing, Internet–based education, and a digital library, among other resources. According to official records, in the year 2000, the VU had seven satellite channels, with approximately 1,280 reception sites in Mexico and 159 additional sites in eleven Latin American countries. The VU also offered 19 master's and one doctoral program in addition to a variety of undergraduate and continuing education programs. Finally, about 6,814 undergraduate and 6,528 graduate students were enrolled in this education modality (ITESM – Universidad Virtual, 2001).

The modus operandi of the VU is characterized by four important features: (1) the "any time, any place" concept of offering flexible

programs for people who have different schedules and who live in different geographical places; (2) the concept of "the added value learning" that comes with the use of technology as the main means for communication; (3) the concept of "cultural enrichment" or the wealth of knowledge that comes when students interact with people from different countries and diverse cultural and professional backgrounds; and (4) "the education for all" concept to increase the accessibility of educational materials (books, journals, videos, CD Rom's, etc.) to places which, historically, have had little or no access.

Paradoxically, there is a remarkable common trait in the five hundred or more courses that are offered each year in the VU: The great heterogeneity shown in the way each course is designed, taught, and evaluated. The VU offers its educational services to different markets and, as a consequence, the characteristics of each course are also different than other courses. For example, while some courses are offered in a quarter–based calendar, others are taught during semester periods. Another example refers to the length of each program: While some programs may require four or more years for completion, other programs may be one–day long. Moreover, there are some continuing education programs for elementary and high–school teachers which are characterized as using "one–way technologies"; that is, communication technologies that only allow students to receive information via TV broadcasting and written materials, but that do not allow them to interact with their instructors or with classmates. However, most of the graduate programs are characterized as using "two–way technologies"; that is, communication technologies that allow students and instructors to interact in synchronous or asynchronous ways.

The course that is analyzed in this case study, Comparative Education, is only one among hundreds offered by the VU. It is a graduate course offered to M.Ed. and Ed.D. students. The instructional design of the course heavily gravitates around the use of satellite and Internet technologies with the purpose of promoting interaction between the students and the learning materials, between the instructor and the students, and among the students themselves. Obviously, there is no attempt to generalize the findings of this case to other courses. As Stake (2000) points out, a case study "draws attention to the question of what specially can be learned from the single case" (p. 435). In the following sections we will draw attention to certain crucial features of the course and the use of PBL, from there we hope to promote a better understanding of this important technique so that it might be used in a different context.

The Contextual Framework of the Course

In the process of setting limits for our case study, we will narrow the contextual framework to the course level. The case study we are presenting in this paper is grounded in the course named "Educación Comparada" (Comparative Education). This is a graduate class taught in a 16-week semester to students of the doctoral program in educational technology and the master's program in educational administration.

Course Population

In 2000, this course was taught to a population of 73 students, 12 of them enrolled in the doctoral program and 61 in the master's program. During this semester, these figures dropped to 54 students (nine from the doctoral program and 45 from the master's program) because of several reasons: Financial difficulties, workload, and limited access to technology. Even though 26% of the student population dropped out, this rate could be considered just a little above the average percentage found in all the graduate courses offered by the VU. The gender ratio was approximately 50/50; and almost all the people who took this course were part-time students, who spend most of their professional time—as school teachers and university professors—in academic activities of their own.

Objectives and Contents

The course on Comparative Education had the purpose of studying the similarities and differences among the educational systems of different countries. In order to teach this course, the content was divided into four major units: (1) The nature of comparative education—what it is, how it is used, and the nature of its historical roots; (2) the characteristics of the educational systems of some countries around the world; (3) the results of comparative studies of the teaching and learning process in different countries; and (4) the comparison of countries in terms of the impact of their educational systems in their development, and vice versa.

Learning Activities

There were four major groups of learning activities designed for this course. The first group of activities was based upon the reading materials selected for each unit of the course. A textbook, Thomas

(1990), together with a large selection of 50 research articles and book chapters were the required and suggested reading materials for the course. In addition, the students also had access to a variety of Web pages and two major journals on comparative education through the digital library. The second group of activities was related to four satellite sessions during the semester. While the broadcasting of these sessions represented a relatively small part of the interaction between students and the instructor, they were important for students to see how the instructor looks and to see how he expresses his ideas. These sessions were also useful for students to know the viewpoints of experts invited *ex professo* for the sessions. The third group of activities asked students to construct several conceptual maps on the readings and the contents of the course. In this activity, each student identified important ideas from the readings and illustrated them in a map that attempted to show the most relevant relationships among the concepts. The fourth group of activities refers to the analysis of seven problems following the PBL teaching and learning technique. This case study refers precisely to this last group of learning activities.

Teaching Team

The VU has an administrative model that is formed of a number of "cells" which can be defined as multidisciplinary teaching teams. A "cell" contains several elements: The main professor, who acts as the team leader; several tutors, depending upon the number of students enrolled in the course; an instructional designer, who mainly acts as an academic quality control manager; a producer, who is in charge of broadcasting the satellite sessions; a graphic designer, who helps all the members of the team to give each course a unique image; and a technology adviser, who is in charge of administering the computer resources in a course. According to the UV administrative model, each cell has some degree of autonomy to design, teach, and evaluate each course.

Technological Platform

Even though the course on Comparative Education had the support of a variety of technologies, most of the interaction between the instructor and the students, and among the students themselves occurred through the use of the Internet. The course used as a technological platform a standard set of interrelated web pages designed by the VU for the graduate courses in the field of education. This standard set of web pages was the chief organizer of other

resources. For example, commercial software for synchronous (Chat) and asynchronous (Hypernews) interaction was linked to the course web pages. In addition, the reading materials were digitalized (prior payment of copyright fees) and linked to the course in the "multimedia" Web page. Finally, other programs designed by the VU for automating specific processes (e.g., self and peer evaluation, course surveys, and so on) were also linked to the course web pages.

Evaluation of Students' Learning

The evaluation of students' achievement of the learning objectives is a major issue in the VU. Because of the distance between the instructor and the student, there is no practical way in which the former could evaluate the performance of the latter under controlled circumstances. Therefore, most of the evaluation process occurs under the assumption that the person who participates in the electronic forums, and who sends the required papers, actually is the person he or she is supposed to be. Accepting this situation, the instructor and the tutors observe students' participations in the forums, receive their papers, and grade both activities according to a set of pre–established criteria. When this is done, the instructor or the tutors give feedback to the students on their learning performances. In the case of the course of Comparative Education, two additional sources of information were added to the instructor's criteria: Self–assessment and peer–assessment of the students.

This brief description of the course serves as a contextual framework for the case we will develop in subsequent sections.

Use of PBL in the Online Course

The idea of using PBL in the course on Comparative Education dates back to 1999. In an effort to explore innovative approaches to teaching and learning, the ITESM contacted several universities in Europe, Canada, and the United States for training courses on teaching techniques, and sent hundreds of its teachers to be trained in these places. The University of Maastricht (UM) (Netherlands) was one of those universities, well–known for its expertise with the use of PBL.

Given that the VU student body is mainly made up of adults, PBL was seen as an *ad hoc* tool for addressing this kind of population. Three major principles of adult learning — what we can call the three C's of an educational process — guide the implementation of educational

programs: Construction, context, and collaboration. First, PBL was seen as an important tool to work under the assumptions delineated by *constructivist* theories of learning. By approaching a given problem systematically, PBL promotes students' interaction with their instructor and among themselves in a dialogical environment in which each other's ideas are tested in a constructive way (Norman & Schmidt, 1992). Second, PBL places students in *contexts* given by a set of problems they have to analyze. The purpose of those problems is not necessarily to resolve them, but just to learn from the situation in which they occur. In that sense, adult learners can more easily relate a real-life problem with the context in which they work, enhancing the transfer of concepts to new problems (Norman & Schmidt, 1992). Finally, PBL seems to be a good tool to foster *collaborative* learning in a systematic way, organizing the different modes of interaction around a given problem. The underlying reasons to promote collaborative learning are two: First, no one has all the competencies needed in the work place to solve today's complex problems; and, second, as a consequence, everybody needs others' competencies to get the job done (Oblinger & Verville, 1998).

The broad experience of the UM with PBL helped ITESM to make the first attempts to use this technique in a variety of courses and programs. However, in the case of the VU, its professors had to face three major challenges: (1) Given that most of UM's experience is in face-to-face educational settings, the first challenge was how to adapt the UM's model to an online course; (2) given that most UM's courses are taught at an undergraduate level, the second challenge was how to adapt the technique to graduate courses; and (3) given that PBL has been used in some UM programs not related to education, the third challenge was adapting the experience to the field of education.

In order to adapt PBL to an online course, several decisions had to be made from the stage of design throughout the implementation of the technique in an actual course. Table 1 (p. xx) shows some issues that were taken into consideration in our effort to adapt the UM's face-to-face approach to PBL to an online course on Comparative Education.

With these ideas in mind, a finer design of the course activities was carried out. The course was structured with seven problems that students were to address during the semester. All problems were taken from real-life situations, although each problem placed the students in a hypothetical role in which they were supposed to emulate a

professional job. For instance, in Problem 1, students confronted a problem oriented towards the analysis of the research trends in a

Table 1
Issues to consider in the adaptation process of the UM's face–to–face approach to PBL to an online course on Comparative Education

Issue to consider	UM's face–to–face approach to PBL	Adaptation of PBL to an online course	Decisions made for the course on Comparative Education
Nature of the interaction	Synchronous face–to–face interaction in the classroom	Synchronous or asynchronous interaction through communication technologies based on Internet	Asynchronous interaction in five problems using Hypernews, and synchronous interaction in two problems using Chat
Length for problem discussion	One week for each problem with two sessions of two hours, one at the beginning of the week (Steps 1 to 5 of PBL) and the other at the end of the week (Step 7 of PBL)	Covering Steps 1 to 5 of PBL, through asynchronous interaction, requires much more time (at least one week)	Two weeks average for each problem in both— synchronous and asynchronous interaction
Group size	Ten to 12 students	No more than four students in a synchronous interaction, and no more that eight students in an asynchronous interaction	An average of five students in each group (no more than six)

Tutor role	Not very important in terms of the interaction with the group	In large classes, such as those that are typical in distance education, the whole group should be divided into smaller groups	Tutors should supervise between 12 and 15 simultaneous discussion groups in asynchronous interaction
Prior students' training on the technique	One week at the beginning of the semester	No special limitations for an online course	Online students' training in the course Web page, and practice along Problem 1
Evaluation of students' learning	Classroom tests under controlled circumstances	No evaluation of students' learning under controlled circumstances, given students' geographical dispersion.	Supervision of group interaction, grading of processes and products for each problem, individual feedback, and self– and peer–evaluation

comparative education journal. In this case, the student had to play the role of an author of journal articles. In Problem 4, a benchmarking situation was proposed to the students, who had to play the role of a school director in search of new ideas. In a similar vein, other problems were designed to simulate professional situations in which students had to play the roles of educational analysts, the people in charge of internationalization projects in major educational institutions, researchers, participants in a congress of education, and leaders of education policy.

The design behind the course on Comparative Education gives enough material for other writings, but with this summary, we complete the contextual framework in which the study on peer interaction took place.

Method for the Study of Peer Interaction

"Case study is not a methodological choice but a choice of what is to be studied. By whatever methods, we choose to study the case" (Stake, 2000, p. 435). Following Stake's philosophy it can be concluded that, from the contextual frameworks that we have previously delineated, many particular cases may arise. However, as we have said elsewhere in this paper, we are going to focus on one aspect of the course-peer interaction.

Sample

Choosing a sample in cases like the one we are discussing requires the definition of a level of analysis. At one level, we may want to sample a group of students from the whole population enrolled in the course. At another level, we may want to sample some electronic forums from the total number of forums that we created for each particular sub–group in each particular problem. At yet a third level of analysis, we may want to sample a number of messages from the total number that were posted by the students in all the electronic forums. At a finer level of analysis, we may even want to sample specific content differences within each message posted by a student. From all the spectrum of possibilities we decided to focus on the messages posted by the students as our level of analysis.

In this case, the sampling process was carried out as follows:

1. Given that the course was taught to students in a master's and doctoral program, from the beginning these two populations were separated and never worked together in the analysis of the problems. In Mexico, as opposed to the U.S., the students can only enter at a doctoral level if they have completed the master's level. This implies that the two populations deserve differential treatments.

2. For each problem, about 15 groups were originally created: The first two were assigned to the 12 doctoral students and the other 13 groups were assigned to the 61 master's students originally enrolled in the course (note that because some students withdrew from the class, these numbers decreased throughout the semester). For the purpose of this study, the sample of students was chosen from two groups of doctoral students and two other groups (randomly chosen) of master's students. Therefore, from the

doctoral level, the sample size was of 12 students out of 12 originally enrolled in the course; while from the master's level, the sample size was also of approximately 12 students out of 61 originally enrolled in the course. It should be noted that these numbers decreased during the semester because of student drop out.

3. Along the semester, students had to address a total of seven problems. The total number of electronic forums that were created for this course was about 90. From them, about 66 forums used an asynchronous form of interaction (in Problems 1 to 5), while 24 used a synchronous one (in Problems 6 and 7). For the purpose of this study, peer interactions were analyzed only from the asynchronous modality (the analysis of synchronous interaction will be discussed in future research). Therefore, if the sample was two doctoral groups plus two master's groups in asynchronous interactions along five problems, then a total of 20 forums was the sample for this study.

4. Because the students' participations in each forum attempted to develop a chain of thought of the members of the group, it was resolved to analyze the total number of messages posted by the students in the 20 forums selected for this study. The total number of messages that was analyzed was 4,508.

It should be noted that, complying with ethical principles of research, a consent form was delivered to all the students enrolled in the course. We asked for their authorization to use their contributions in the groups, and we assured them that the reports would contain only general information of the groups, and never particular descriptions that could identify them as individuals.

Instruments

Each particular message, from the sample of 4,508, was coded in a form with categories clearly defined from the onset of the study. The first set of categories referred to the different levels in which a message can be posted in a Hypernews electronic forum: Level 1, Level 2, Level 3, and so on. The first level is the beginning of a new thread, which means a new idea different from the previous ones within the forum. The second level implies a response to a message in Level 1. The third level implies a response to a message in Level 2, and so on. While some threads contain only one message in Level 1, others could have

messages in more than one level. Nine was the maximum number of levels that a thread contained in the forums sampled for this study. Because Hypernews automatically organizes each thread, the codification of each message in each level was not affected by any coder's interpretation.

The second set of categories referred to whether or not a particular message posted by a student belongs to one particular step of the seven steps associated with the PBL technique. Since the course was designed with UM's model of PBL, the seven categories or steps are: (1) Clarification of terms; (2) problem definition; (3) brainstorming; (4) classification of contributions; (5) definition of the learning goals; (6) independent studying; and (7) report of findings. It should be noted that not all the messages posted in an electronic forum related with the PBL seven steps. While some messages were for greeting other peers, others were devoted to the internal organization of the team. Therefore, not all the messages classified in the first set of categories were devoted to the PBL technique. It should also be noted that even if the codification processes may be subjective in this part of the investigation, still there is little margin of error since group members were regulating themselves in each one of the PBL steps and making explicit in their contributions where they were.

The third set of categories referred to whether or not a particular message contributed in some way to a collaborative learning. By collaborative learning we understand the process by which students work in teams with the purpose of constructing knowledge and achieving some learning goals. For the purpose of this study, five categories (extracted from the work of Gunawardena, Lowe, & Anderson, 1997) were used: (1) Comparison of information; (2) dissonances and inconsistencies; (3) negotiations and co–constructions; (4) tests and changes of what has been co–constructed; and (5) agreements and applications. As mentioned before, not all the messages posted in an electronic forum were necessarily directed to what we defined as collaborative learning.

Procedure

The codification process involved a previous training of the coder and a pilot study to test the functionality of the instrument. When this was done, and the forums were selected for the study, the codification of each message was carried out and descriptive statistics were used to analyze the collected data.

Results and Discussion

In order to study the patterns of interaction among students in this course, several descriptive statistical analyses were carried out. The results and the discussion were organized around four major topics: (1) Threads of thought generated in electronic forums; (2) the efficient use of the electronic forums in the study of the problem; (3) the level of mastery of the PBL technique accomplished by students in an online course; and (4) the effectiveness of PBL for fostering collaborative learning.

Threads of Thought: Levels of the Posted Messages in Electronic Forums

The first analysis was conducted with the data collected from the number of messages posted in electronic forums at different levels (Level 1, Level 2, Level 3, etc.). Table 2 (p. xx) shows a summary of the total number of messages posted by the students in the five problems, the mean and the standard deviation of the number of messages posted by each student in each forum, and the proportion of messages at each level in relation to the total number of messages at all levels. These numbers are calculated for both—the forums for students in the doctoral program and the forums for students in the master's program.

A much larger proportion of messages was posted at a first and a second level than in the remaining levels. In the case of the doctoral forums, 26.25% and 32.53% of the messages were posted at Levels 1 and 2, respectively. Together, this means that 58.78% of the messages corresponds to the first two levels. In the case of the master's forums, 47.14% and 32.89% of the messages were posted at Levels 1 and 2, respectively. Together, this means that 80.03% of the messages also corresponds to the first two levels.

The numbers shown in the preceding paragraph are an index of how students use a tool like Hypernews for asynchronous communication. The underlying advantage of this kind of software is to enable students to follow the track of threads of thought until they are resolved. It is assumed that significant learning occurs when a dilemma is solved and conclusions are reached on a specific topic. Additionally, Hypernews gives order to how students discuss and reply to each other in a dialog that aims to promote the development of new structures of knowledge.

When most of the contributions in one forum are placed at a first level (or at the two first levels), two interpretations are at hand: It may mean that most of the students' ideas are relatively independent from each other, or that students do not know how to use efficiently the electronic communication software. The great contrast of 80.03% of the master students' contributions at Levels 1 and 2, with the 58.78% of the doctoral students in the same levels, leads us to infer that doctoral students are using Hypernews in a more appropriate way. Additionally, this becomes even more evident when we compare both groups throughout the other levels. In general, the students in the doctoral group appear to give greater continuity to their discussions than students in the master's group. However, these inferences are only tentative, since a closer look to the content of each message, rather than just the number of messages, may confirm or disconfirm our inferences.

In any case, these numbers are an index that should be taken into account when the instructor is designing asynchronous interactions in an online course. Some form of training on the use of the communication tool, together with a good illustration on how the tool works are important forms of scaffolding to help students to develop the full potential of this mode of interaction and thus to help them to construct their knowledge. If the students are oblivious to these characteristics of the technology, they will post their messages to create a mere set of isolated ideas without expectancies of receiving a reply.

Efficiency in the Study of the Problem: Focus on PBL within the General Discussion

The number of messages in an electronic forum by itself tells us something about the level of interaction manifested around a discussion topic (a "problem", in PBL). However, a second question demands an answer: What can each message tell us about the quality of this interaction? For instance, it is important to know to what extent the interaction was devoted to a guided discussion according to the PBL canons. The purpose of this second analysis is to find out precisely how much of the contents in the sample messages focused on PBL.

As stated elsewhere, each particular message was coded as pertaining to one particular step of the seven steps associated with the PBL technique. Thus, from the pool of messages, many of them were discarded because they had other purposes different from addressing a

Table 2

Levels of the posted messages in electronic forums

Level	Doctoral program				Master's program			
	n [a]	M [b]	SD [c]	% [d]	n [a]	M [b]	SD [c]	% [d]
Level 1	789	16.10	10.69	26.25	708	12.42	10.94	47.14
Level 2	978	19.96	16.14	32.53	494	8.67	8.56	32.89
Level 3	545	11.12	11.66	18.13	176	3.09	3.69	11.72
Level 4	341	6.96	7.65	11.34	76	1.33	3.54	5.06
Level 5	190	3.88	5.22	6.32	39	0.68	1.59	2.60
Level 6	91	1.86	2.98	3.03	4	0.07	0.42	0.27
Level 7	46	0.94	1.96	1.53	2	0.04	0.19	0.13
Level 8	17	0.35	1.01	0.57	2	0.04	0.26	0.13
Level 9	9	0.18	0.73	0.30	1	0.02	0.13	0.07
Sum	3,006	61.35	—	100.00	1,502	26.35	—	100.00

[a] Total number of messages posted in the five problems
[b] Mean of the number of messages posted by each student in each forum
[c] Standard deviation of the number of messages posted by each student in each forum
[d] Proportion of messages at each level, in relation to the total number of messages at all levels

specific PBL step (e.g., greeting some classmates or regulating the group discussion).

Table 3 shows a summary of the total number of messages posted by the students in the five problems, and associated with each one of the PBL seven steps. The table also shows the proportion of messages at each PBL step, in relation to the total number of messages associated with the PBL seven steps; and the proportion of messages at each PBL step, in relation to the total number of messages at all levels. These numbers are calculated for both academic levels: doctoral students' participations and their master degree counterparts.

The first thing that calls our attention when we analyze these numbers is that only 17.66% (531 out of 3,006) of the messages posted by the students in the doctoral program resulted to be relevant to one of the seven PBL steps, and only 31.36% (471 out of 1,502) of the messages posted by the students in the master's program resulted relevant in the same category. At first sight, these numbers indicate that both groups used a relatively small part of their posted messages in a direct connection to the structured steps given by the PBL technique. Apparently, the students in the master's group were more focused than the students in the doctoral program when posting their contributions in concordance with the PBL technique. However, this supposed efficiency in the master's group deserves a more careful look. When we analyzed the contents of each message, we appreciated that students in the doctoral program invested a great number of messages in group–regulated process, which hinted at some collaborative work toward a joint construction of knowledge. In contrast, contributions from students in the master's program appear to be more isolated, with little effort to link or contrast a posting with others. The tentative explanation will be addressed later in this paper.

As it is shown in Table 3, some calculations were made to evaluate the proportion of messages at each PBL step, in relation to the total number of messages associated with the PBL seven steps (this total taken as the 100%). In this case, students in the doctoral program seem to place much more emphasis on the five first steps (77.77%) than the students in the master's group (37.37%). In contrast, when we observe only Step 6, we counted only 16.76% of the messages posted by students in the doctoral program, in contrast to 55.84% of the messages posted by the students in the master's program. This leads us to an interesting reflection when we compare this form of asynchronous interaction to the traditional "face to face" modality of using PBL (to

Table 3

Proportions of messages at each PBL step

PBL step	Doctoral program			Master's program		
	n^a	$\%_{PBL}{}^b$	$\%_{Total}{}^c$	n^a	$\%_{PBL}{}^b$	$\%_{Total}{}^c$
Step 1: Clarification of terms	137	25.80	4.56	38	8.07	2.53
Step 2: Problem definition	70	13.18	2.33	44	9.34	2.93
Step 3: Brainstorming	72	13.56	2.40	38	8.07	2.53
Step 4: Classification of contributions	46	8.66	1.53	12	2.55	0.80
Step 5: Definition of the learning goals	88	16.57	2.93	44	9.34	2.93
Step 6: Independent studying	89	16.76	2.96	263	55.84	17.51
Step 7: Report of findings	29	5.46	0.96	32	6.79	2.13
All the steps	531	—	17.66	471	—	31.36
Sum	—	100.00	—	—	100.00	—

[a] Total number of messages posted in the five problems and associated with each one of the PBL seven steps

[b] Proportion of messages at each PBL step, in relation to the total number of messages associated with the PBL seven steps (531 for the doctoral program and 471 for the master's program)

[c] Proportion of messages at each PBL step, in relation to the total number of messages at all levels (3,006 for the doctoral program and 1,502 for the master's program)

say, in the University of Maastricht, as an instance). In the "face to face" modality, students usually spend a two–hour session at the beginning of the week to address the five first steps of the PBL technique. Then, students engage in independent study in agreement with their learning goals defined by the discussion group. At the end of the week, students get together again, in a two–hour session, to compare their findings, try to solve the problem, and learn from it. In contrast, in an "online" modality with asynchronous interaction, it takes the students about two weeks average per problem, working through the seven steps. Going back to Table 3, what we observed in this analysis is that students in different groups (doctoral vs. master's) appear to place different importance on different steps. A tentative explanation for this may be found in the literature on expert–novice differences (e.g., Chi, Glaser, & Farr, 1988). According to this work, experts tend to invest more time in understanding the problem and defining a clear strategy of what the problem requires to be solved than novices. The latter tend to engage quickly in the solution of a problem even if it is not well understood. Certainly, a master student is not precisely a "novice", but it may be assumed that, in general, doctoral students surpass master students in a *continuum* of expertise in higher–order thinking skills. These ideas may explain why doctoral students invested more time and effort in the five first steps of the PBL technique than did students in the master's program.

By conducting a more qualitative analysis of the messages, it was possible to gain additional insights which allow us to better understand the relative emphasis given by each group to each PBL step. From a close look at the contents of each message, we observed that students in the doctoral group tended to use Hypernews almost as a synchronous tool of communication. The members of each particular group tended to meet in the "virtual classroom" at a specific time, and they used to interact in sessions of two or three hours in a more collaborative way. At the beginning of each problem, these students were focused on clearly defining each possible term, not mattering how obvious its meaning could appear (notice that about one fourth of the messages devoted to the PBL steps refer to Step 1). Along the discussion, students were also concerned with the rigorous analysis of the problem and the process of sharing their own personal experiences. At the end, a great amount of effort was spent in the process of submitting a final product with the consensus of all.

In contrast, students in the master's group were more focused with trying to solve a problem, with little or no concern with the process that

it may require to reach such solution. Creating a product, instead of discussing and reflecting, seems to be the underlying and unifying characteristic of these students. Accordingly, students in the master's program did not devote great effort to clarifying the concepts of the problem. They appear to be more concerned with demonstrating that they had researched enough the topic associated with the problem, and then they pasted a great number of web pages as a proof that they did the homework (notice that more than half of the messages devoted to the PBL steps refer to Step 6). Having done this the master's students only pulled together the pieces that each one researched with little concern for generating an integrated and coherent product.

From all these analyses, we can infer that different students appear to place different importance on each step of the PBL technique. However, the relative importance given to each step may have its origin in other factors. The nature of the problem, for example, may affect whether a student needs to invest more time in clarifying some terms or needs to engage in independent study. In this case study, this variable was left out from our analysis and, indeed, it may be a crucial factor to take into account for further research. In summary one important result of this research is that, for any one using PBL, it is essential to understand the purpose of each PBL step as instrumental for obtaining a meaningful learning from the educational experience.

Level of Mastery of the PBL Technique: Changes in the Use of PBL throughout Time

As a part of the instructional design a special section of the web page was devoted to show students how to work with the PBL technique. Students were instructed to read that section before starting their work on the first problem. Particularly, in this first problem, the tutors had the special task of clarifying the nature of PBL and explaining the way they were to engage in each one of the seven steps. In subsequent problems, tutors' guidance gradually decreased since students were supposedly increasing their level of mastery of the PBL technique.

We proceed now to analyze the reasonableness of these suppositions. Can we really assume that students tended to apply the PBL technique better as they had more experience with its use? How can we find out whether some changes really occur in the use of PBL throughout time?

Figure 1 (p. xx) shows a pair of graphs illustrating some changes in the use of PBL throughout time. The "x" axis contains each one of the five problems given to the students in a period of about 10 weeks (an average of two weeks per problem). The "y" axis represents the average number of messages (absolute and associated with PBL), per person, posted in each problem. These graphs show the figures for both—the forums for students in the doctoral program and the forums for students in the master's program.

Given the exploratory nature of this study, no hypothesis was stated *a priori* regarding the trend of students' participation throughout time. The results show no clear trend either. Looking at the "ups and downs" of each graph, it is difficult to obtain a clear conclusion about not only the trend of participations, but also about the mere possibility of existence of such trend. This is comprehensible since frequency and quality of peer interaction in a given time period may be affected by countless variables within and outside the course context. In spite of this, a qualitative analysis of each message may give us some insight of what is going on in the dynamics of these two groups.

The first thing that shows up from Figure 1, Problem 1, is the disparity in the average number of messages per person between the students in the doctoral program (96.40) and students in the master's program (21.40). In this particular case, the cause of this difference seems to be due to what was already said before: Students in the doctoral group tended to use Hypernews almost as a synchronous tool of communication. This form of use of Hypernews motivated that some participations had almost an automatic response from other group members, converting this software as some kind of "chat" space. In contrast, students in the master's program appear to use Hypernews in a more asynchronous way, most likely motivated by the fact that this kind of students does not always have easy access to computer resources of their own, making it difficult to spend the amount of time that doctoral students usually do.

It is important to observe that the gap between these two groups did not remain so wide during the semester. In Problem 5, these two groups almost coincide in the average number of participations per person (about 28). Even if the trend in the doctoral group had one "down" and one "up", the general tendency apparently was to decrease the frequency of participation. One explanation of this tendency is that students in the doctoral group could not sustain such "intensity" of participation during the whole semester. Another explanation of these

Figure 1
Changes in the Use of PBL Throughout Time
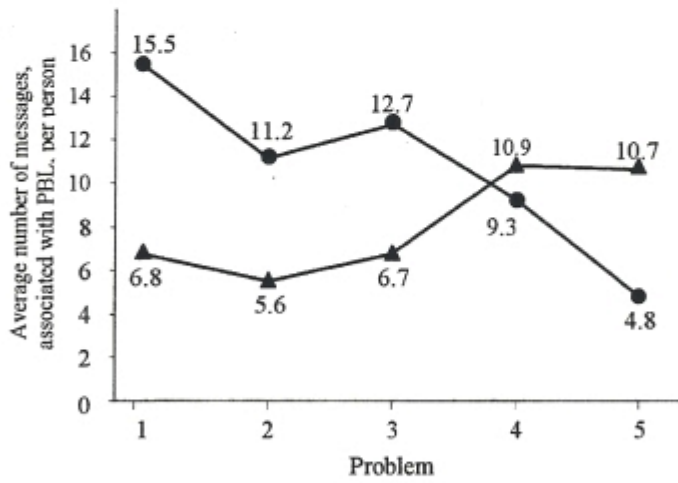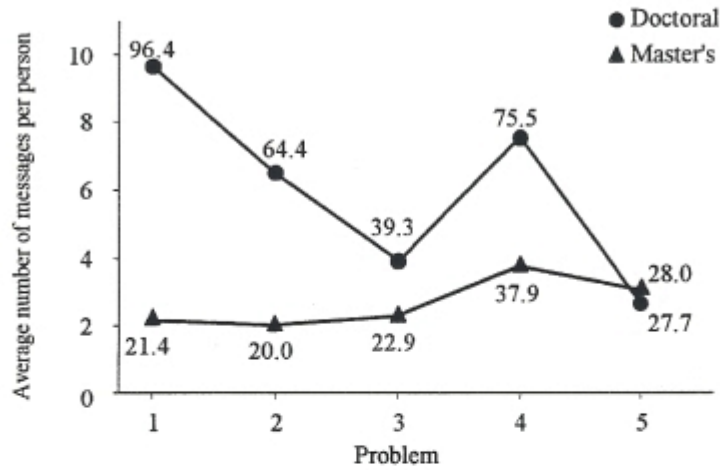
results (which does not exclude the first one) is that the doctoral students quickly developed an understanding of the PBL technique to a degree that subsequent interactions did not demand all the effort spent at the beginning. In contrast to these figures, the trend in the master's group remained more stable, in a range between 20.09 and 37.92 messages per person and per problem.

The second graph of Figure 1 shows two different trends in relation to the number of messages directly related to the PBL steps. In general, the trend for the doctoral group is to decrease over time, while the trend for the master's group is to increase in the average number of participations per person in the seven steps. This may be explained by the role of the tutors in charge of monitoring each group. Given that doctoral students tend to work in a more autonomous and group–regulated bases, the role of their tutor was less controlling. In contrast, in the master's group, the role of the tutor was more directive or supportive since these students tend to be more dependent on external guidance. The tutors then may have helped students to focus their discussions more on each PBL step.

It is also important to notice that some students (mainly doctoral students) took specific steps to make their discussion work more efficiently. Particularly in the last forums, one can appreciate that from the very beginning a "team leader" in each doctoral group opened some messages as a "title" for each one of the seven PBL steps. In this way, Hypernews was used more efficiently and the messages were more focused on the PBL steps.

In summary, the way tutoring is conducted, and the training process, seem to be two crucial factors to define the way students approach the PBL technique, and the way they develop strategies to work within an online environment.

Effectiveness of PBL: Contributions to Students' Collaborative Learning

Working in teams is not equivalent to teamwork. A common mistake in the design of online courses usually refers to the idea that just including a forum for discussion in small teams is enough to guarantee that meaningful learning will occur. Probably the most important result of this investigation is precisely that meaningful learning in an electronic forum will not happen by itself. Authentic collaborative learning implies much more than only pulling together

the individual contributions from each member of a group. Collaborative learning implies comparing the information that each member brings to the discussion table. It also requires identifying differences and inconsistencies in such information. Then, when these differences and inconsistencies are found, collaborative learning requires that the team members "negotiate" meanings and construct together new knowledge until they reach some agreements (Gunawardena, Lowe, & Anderson, 1997).

As a teaching and learning technique, PBL is a tool that gives students some structure or framework to work together towards one or more goals. But, how much is PBL really promoting students' collaborative learning? Strictly speaking, this question cannot be answered in the context of this case study. A cause–and–effect relationship between PBL and collaborative learning cannot be found in this research study. However, some conclusions may be inferred from the figures associated with this last analysis.

Table 4 (p. xx) shows a summary of the total number of messages posted by the students in the five problems, and associated with each one the processes of collaborative learning, as defined by Gunawardena, Lowe, and Anderson (1997). The table also shows the proportion of messages at each process of collaborative learning, in relation to the total number of messages associated with all the processes taken together. Additionally it shows the proportion of messages at each process of collaborative learning, in relation to the total number of messages at all levels. These numbers were calculated for both—the forums for students in the doctoral program and the forums for students in the master's program.

Three major conclusions are driven from Table 4. First, in all the processes of collaborative learning, doctoral students surpassed master's students by more than twice (485 vs. 230, respectively). This is consistent with what has been said in the preceding sections. From a close look at the contents of each discussion group, students in the doctoral group engaged in a much more collaborative interaction than their master degree counterparts.

Second, both groups of students appear to place more importance on the process of "negotiation and co–construction", followed by the process of "dissonances and inconsistencies", than the other processes. In fact, more than half of these messages were devoted to these two processes, while the other four collected less than the other half. This

Process of collaborative learning	Doctoral program			Master's program		
	n^a	%$_{Coll}$^{b}	%$_{Total}$^{c}	n^a	%$_{Coll}$^{b}	%$_{Total}$^{c}
Comparison of information	78	16.08	2.59	51	22.17	3.40
Dissonances and inconsistencies	97	20.00	3.23	63	27.40	4.19
Negotiations and co–constructions	192	39.59	6.39	71	30.87	4.73
Tests and changes of what has been co–constructed	56	11.55	1.86	28	12.17	1.86
Agreements and applications	62	12.78	2.06	17	7.39	1.13
All the processes	485	—	16.13	230	—	15.31
Sum	—	100.00	—	—	100.00	—

[a]   Total number of messages posted in the five problems and associated with each one of the processes
of collaborative learning

[b]   Proportion of messages at each process of collaborative learning, in relation to the total number
of messages associated with all the processes taken together (485 for the doctoral program and 230
for the master's program)

[c]   Proportion of messages at each process of collaborative learning, in relation to the total number
of messages at all levels (3,006 for the doctoral program and 1,502 for the master's program)

tells us that even if some aspects of collaborative learning are present, students may not be placing enough emphasis on "wrap up" processes in search of consensual agreements.

Third, in both cases, the accumulative proportion of messages associated with all processes of collaborative learning represents only 16.13% (485 out of 3,006) for the doctoral group, and 15.31% (230 out of 1,502) for the master's group, from the total number of messages at all levels. If the final purpose of peer interaction is to promote collaborative learning by using PBL, these figures tell us that the purpose is relatively poorly fulfilled.

PBL seems to be a good technique to guide students throughout the process of solving and learning from a problem. However, it also appears that following the technique of PBL by itself is not enough to assure that students will engage in an authentic collaborative learning. Special training toward that end seems to be a *sine qua non* condition, though may not be a sufficient condition, to increase the likelihood for learning in a collaborative manner.

Closing Statement

A case study, as the one here presented, allows us to contemplate the educational characteristics of PBL in a naturalistic and holistic way. As a result of this type of inquiry, this case attempts to represent a particular teaching and learning experience displaying for the reader many of the teachers' implicit assumptions related to the design of the course. Moreover, the case points out effective and not–so–effective decisions made from the beginning to the end of the course so that successes may be replicated and problems avoided in future designs. As a holistic inquiry, this case faces us with countless variables that affect the efficiency and effectiveness of the course and help us to sketch the tremendous complexities of the intellectual game of collaborative problem solving. The design of the learning environment, the selection of a technological tool of communication, the nature of the problems, the tutors' choices of interaction with the students, the students' prior experience in distance education modalities, the presence or absence of training in the use of PBL and more, all of them appear to affect in intricate dynamics the way students interact and learn to solve problems in a collaborative manner. Grasping the interplay among all these factors is the challenge that we teachers, designers of classes of PBL online, have to face to improve our professional practice.

Author's Note

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