Journal of University Teaching & Learning Practice

Volume 8 | Issue 1 Article 4

2011

The Pros and Cons of Problem-Based Learning from the Teacher's Standpoint

Luis Roberto C. Ribeiro
Universidade Federal de São Carlos, Brazil, rcr.luis@gmail.com

Recommended Citation

Ribeiro, L. C. (2011). The Pros and Cons of Problem-Based Learning from the Teacher's Standpoint. *Journal of University Teaching & Learning Practice, 8*(1), 34-51. https://doi.org/10.53761/1.8.1.4

The Pros and Cons of Problem-Based Learning from the Teacher's Standpoint

Abstract

This article focuses on a teacher's evaluation of an experiment with problem-based learning (PBL) and its effects on his professional development. This case study, of a descriptive-analytical nature, involved the collaboration between the researcher and teacher in the planning, implementation of PBL and, to some extent, analysis of results. Research data—collected via participant observation of classes and open-ended interviews with the teacher—were analyzed in light of the literature on PBL, teacher knowledge base, and professional development. Results indicate teacher satisfaction, but also point to higher class unpredictability and increased time/workload. PBL also seems to distribute teaching workload more evenly throughout the semester than traditional methods do. This hinders routinisation and constrains teachers' autonomy. On the other hand PBL appeared to foster the teacher's development of his teaching knowledge base, especially regarding the knowledge of students, their reasoning mode and interests.

Keywords

Problem-Based Learning, Teacher Development, Teaching-Learning Processes, Higher Education

Journal of University Teaching & Learning Practice

Volume 8 | Issue 1 Article 4

2011

The Pros and Cons of Problem-Based Learning from the Teacher's Standpoint

Luis Roberto C. Ribeiro
Universidade Federal de São Carlos, rcr.luis@gmail.com

The Pros and Cons of Problem-Based Learning from the Teacher's Standpoint

Abstract

This article focuses on a teacher's evaluation of an experiment with problem-based learning (PBL) and its effects on his professional development. This case study, of a descriptive-analytical nature, involved the collaboration between the researcher and teacher in the planning, implementation of PBL and, to some extent, analysis of results. Research data—collected via participant observation of classes and open-ended interviews with the teacher—were analyzed in light of the literature on PBL, teacher knowledge base, and professional development. Results indicate teacher satisfaction, but also point to higher class unpredictability and increased time/workload. PBL also seems to distribute teaching workload more evenly throughout the semester than traditional methods do. This hinders routinisation and constrains teachers' autonomy. On the other hand PBL appeared to foster the teacher's development of his teaching knowledge base, especially regarding the knowledge of students, their reasoning mode and interests.

Keywords

Problem-Based Learning, Teacher Development, Teaching-Learning Processes, Higher Education

Introduction

The technological revolution of the last decades has affected higher education in many, often contradictory, ways. It has expanded the volume of knowledge students are expected to learn during undergraduate years while speeding its obsolescence. This fact, aggravated by the increasing instability and competitiveness of the job market, requires that professional education in general go beyond the mere transmission/reception of technical-scientific information. This situation has been widely recognized by many scholars of higher education, who suggest that professional skills and attitudes be promoted in conjunction with a solid scientific knowledge base. Among the skills and attitudes are the capacity to solve problems and make informed decisions and the disposition for self-directed and life-long learning (Bok, 1986). That is to say that knowledge should be taught so as to enable students to deal with unforeseen and uncertain events and to adapt their professional development accordingly throughout their careers (Delors, 1999).

It seems that it no longer suffices to teach students – especially in engineering education, the focus of this article – how to memorize a fixed body of knowledge. On the contrary, colleges and universities should prepare students to generate, apply and disseminate knowledge as well as to perform well professionally, which may be accomplished through curricula that promote students' understanding of general and specific knowledge, development of critical and conceptual reasoning, integration of theory to practice, development of interpersonal, written and oral communication skills and the capacity to reflect on their own practices and learn from practical situations (Atkins cited by Tynjälä, 1999). In fact, these suggestions are in agreement with what has been recommended by surveys of desired profiles of professionals, which point out that schools should aim beyond the students' mastery of conceptual knowledge. With respect to the profession for which the students in this study are being prepared, the profiles of engineers consistently indicate that procedural knowledge, such as written and oral communication skills, teamwork skills, problem-solving skills and self-directed learning skills, and attitudinal knowledge, such as disposition for life-long and self-directed learning, respect for other people's opinions, ethical behaviour, concern for the community's welfare and for the environment, are also vital to the students' future as successful engineers and conscientious citizens (e.g., Vasilca, 1994; Ning, 1995).

Although the relevance of these three types of knowledge is generally acknowledged by higher education faculty and administrators, their advancement poses a great challenge to universities and colleges: how to promote the acquisition of an increasing body of technical and scientific knowledge while fostering the development of other types of knowledge, such as skills and attitudes, without overburdening the curricula or extending the period of formal training? Needless to say that there is no simple answer to this question, as it involves considerable institutional, cultural and individual changes. However, on the classroom level, this may be attempted by adopting instructional approaches that integrate the three types of knowledge, i.e., conceptual knowledge, procedural knowledge and attitudinal knowledge (Zabala, 1998). It seems that among these approaches, Problem-based Learning (PBL) is capable of providing students with opportunities to learn conceptual knowledge and develop the skills and attitudes valued in their chosen careers – as well as in society at large – without the need to extend or overburden the curricula (Savin-Baden, 2000).

Problem-Based Learning (PBL)

Originated in the 1960s at McMaster University Medical School, Canada, PBL is essentially a collaborative, constructivist, and contextualized learning and teaching approach that uses real-life problems to initiate, motivate and focus knowledge construction. According to Schmidt (1993), PBL is grounded on Jerome Bruner's notion that epistemic (intrinsic) motivation acts as an internal force driving people to better understand the world and on John Dewey's principle of autonomous learning and emphasis on learning in answer to – and in interaction with – real-life events. Indeed, PBL is based on the assumption that learning is not a process of reception, but of construction of new knowledge. It is supported by cognitive science theory that spouses that previous knowledge about something can determine the nature and the amount of information students can process and elaborate in order to be internalized (Regehr & Norman, 1996). In addition, PBL is supported by cognitive research results that suggest that meta-cognition and social factors have a strong influence on learning (Gijselaers, 1996).

The PBL Process

Despite its origin in the teaching of medical and health sciences, PBL rapidly expanded to the teaching of other disciplines, such as engineering (e.g., Woods, 1996) and business administration (e.g., Stinson & Milter, 1996). However, in order to adapt to diverse fields of knowledge and educational contexts, PBL has taken up different formats from that of McMaster. PBL in medical education is usually implemented curriculum-wide, i.e., the problems are the core of the curriculum and all knowledge needed to solve them is ultimately sought by the students. Another common PBL format is the hybrid model, which is also curriculum-wide, but comprises pre-established subjects that inform the problem solving process (e.g., Kingsland, 1993), which may be taught conventionally, e.g., by means of lectures, seminars, and laboratories.

In addition to these formats, PBL has also been extensively employed as a partial approach, i.e., in single subjects in otherwise conventional/lecture-based curricula (e.g., Duch et al., 2001) and at given points of lecture-based subjects (also known as 'post-holing'). These alternative formats share with the curriculum-wide models the fact that they encourage the students' teamwork with authentic or simulated real-life problems, which are posed to them before focal concepts and theories are introduced or discussed. This principle is considered by Barrows (1996, p. 7) as "the irreducible core of PBL" and distinguishes it from other active, co-operative, student-centred, process-centred or case-based educational approaches.

This principle is also the pillar of the PBL process, which may be summarized as follows: (1) a problem is presented to students, who, in small groups, organize their ideas, evaluate it, define its nature and try to solve it with available knowledge; (2) then students discuss the problem and identify aspects of it that need clarification and research (learning issues); (3) subsequently they prioritize the issues and plan when, who, where and how these issues will be investigated; (4) when the students meet again, they share and explore the knowledge gathered about the learning issues and use it to propose an informed solution to the problem (if a satisfactory solution cannot be reached, they may have to restart the cycle); and (5) after finishing working with the problem, the students assess themselves, their peers (group members) and the process/problem (Barrows, 2001).

Teaching in PBL

In spite of its apparent simplicity, not only does the adoption of the PBL process involve administrative and educational changes, but it also demands significant individual changes, such as different roles of students and faculty. While students are required to take up more responsibility for their learning, teachers have to relinquish the role of imparter of established scientific knowledge and valuator of the knowledge reproduced by students. Additionally, teaching in a PBL environment is quite different from what takes place in higher education institutions. Faculty at these institutions, especially at research universities, usually plan and teach their classes in isolation and are more interested in research than in teaching, a familiar depiction of teaching in engineering education.

On top, one of the key characteristics of engineering faculty – and most higher education teachers – is their lack of pedagogic training. In engineering education, it is likely that the majority of teachers come directly from baccalaureates and graduate programs with scarce or no teaching theory or practice. This deficiency does not even seem to be an obstacle when hiring faculty, since it is believed – by institutions and applicants alike – that those who know necessarily know how to teach. This is a paradox *per se,* as many colleges and universities recognize the worth of pedagogical knowledge by granting teaching diplomas.

It is true that much has been done to improve teaching at the postsecondary level, e.g., the establishment of teaching laboratories. However, most research universities inadvertently sabotage their faculty's desire to develop their teaching knowledge base by setting up promotion criteria primarily focused on research achievements. This resembles the establishment of quantified targets in mass production, which Deming (1986) criticized because it encouraged workers to do whatever was needed to reach them at the expense of product quality. Analogously, the overvaluing of research and publications in higher education is, perhaps, the main reason for poor quality in undergraduate education.

This is not to imply that research is not important to teaching at the postsecondary level. First and foremost, universities today cannot do without the funds derived from research activities. Secondly, although there has been much controversy as to whether all teachers should necessarily do research; it is important to remark that doing research is a good way of keeping up with new knowledge generated in their field – a vital issue in an age of fast changes. Thence, there should be an effort to reach a balance between research and teaching, two central purposes of higher education institutions.

At any rate, the lack of pedagogical training aggravated by the characteristics of the university classroom – constricted and with a great number of students at different levels of motivation – pushes the teacher to adopt lecture-based teaching methodologies. This appears to be more common in the teaching of content-heavy disciplines such as the 'hard' sciences (Menges & Austin, 2001). Besides, teachers of these disciplines are known to be strongly influenced by positivism. As a result, they tend to prize the accumulation of knowledge, which, given the aforementioned expansion rate of knowledge – particularly of the kind with immediate technological application – can only be effectively achieved through theory-packed lectures with minimal participation of students (ideally none).

In contrast, PBL teachers should, instead of merely transmitting information, interact with the students at the meta-cognitive level, questioning superficial reasoning and vague and erroneous

concepts (Savery & Duffy, 1998). This new role as co-learner, guide and facilitator in the construction of knowledge is one of the great challenges that PBL poses to teachers and institutions. Also, the literature on PBL indicates that teaching demands more participation, planning, cooperation with colleagues, administrators, employers of students and society, and shared decision-making in this educational environment approach than in conventional, lecture-based ones.

Likewise, PBL involves more complex and uncertain teaching situations than those found in lectures. These aspects gain importance if it is acknowledged that higher education belongs in adult education. Mizukami and colleagues (2002) believe that in order to achieve success in this context teachers should not only be able to diagnose and know their students, but also to evaluate, improve and constantly renew their practice. Hence, since these abilities are not innate, it is clear that teachers have to be trained to work with PBL. However, there is little literature on the professional development of teachers that have had no formal pedagogical training, as is the case of most university faculty. Furthermore, it seems that teacher education through short courses or workshops on didactics and teaching methods does not suffice (Mizukami et al., 2002; Menges & Austin, 2001). The literature on teacher education that better fits this context (i.e., continued teacher education) points to training anchored in teachers' practice, everyday classroom activities and real-life problems in a participative, flexible and investigative manner (Marcelo Garcia, 1992).

Besides encouraging teachers' critical and reflective practice, this perspective of continued education is consistent with the education of professionals founded on the epistemology of practice (Schön, 1991). This mode of education seeks to minimize the Taylorist dichotomy between those who think and those who execute, those who produce knowledge and those who apply it, theory and practice, and educational researchers and teachers. To reach this goal Candau (1996) suggests that the locus of continued education be dislodged from universities and colleges – the locus of professional education par excellence – to the workplace of teachers. Moreover, this education should be structured around problems and projects instead of academic contents and take into account the phases of teachers' careers and lives as theorized by Huberman (1995) and Sikes (1985), respectively.

Among several existing modes of continued education at the workplace, the collaboration between educational researchers and teachers has been indicated as one that best favours the professional development of both parties (Mizukami et al. 2002). This is because collaboration between teachers and researchers provides them with opportunities to reflect on their practice, reveal opinions and criticisms, and support each other's changes. What is more, collaboration can bring together these parties and the knowledge produced by them. Thus, collaboration may contribute to lessen negative feelings nurtured by teachers as regards academic research, attributed by Zeichner (2000) to the devaluation of teachers' knowledge, the hermetic language used by researchers and the feeling harboured by teachers that they are exploited by researchers and are seldom informed about the final results and conclusions of research to which they contributed. On top, this collaboration could help to dissipate the belief of many a teacher that educational research is irrelevant to their profession, which causes them not to seek it to enlighten and improve their practice.

Finally, while not wishing to imply that PBL teachers can do without formal pedagogic training, it appears that this approach, *per se*, may be an important tool in fostering the development of the their knowledge base (Quinlan, 2003). Shulman (1987) defines the teacher knowledge base as comprising content knowledge, general pedagogical knowledge, curriculum knowledge, knowledge of students and their characteristics, knowledge of the educational context, knowledge

of educational ends, and pedagogical content knowledge (i.e., how teachers combine their content knowledge with other types of knowledge to promote students' learning). Because a large amount of professional knowledge is believed to be constructed through a process of reflection on practice (Schön, 1983), the on-going assessment and feedback activities inherent to PBL may actually boost the development of the teacher knowledge base.

Research in PBL

Since its origin the effects of PBL have been widely investigated, resulting in numerous studies, which have been synthesized and analysed by Albanese and Mitchell (1993), Vernon and Blake (1993) and, more recently, Dochy et al. (2003). The results of these meta-analyses point to important gains for students, such as the establishment of an intellectually challenging, flexible and enjoyable learning environment marked by camaraderie and collaboration (among themselves and among them and their teachers). In addition, despite some studies indicating a small difference in knowledge acquisition in favour of more conventional approaches, the literature strongly suggests that PBL promotes the students' professional skills and attitudes. Parenthetically, this difference is disputed by many authors (e.g., Stinson & Milter, 1996) because it is based on results deriving from standardized objective tests that primarily measure the students' ability to memorize concepts out of context. Also, the above meta-analyses point to PBL students acquiring better study habits (e.g., more focus, more commitment, and more effective use of educational resources) as compared to conventional methodologies, implying that it is capable of promoting life-long and self-directed learning.

As regards teachers, Albanese and Mitchell's (1993) meta-study indicates that the most of them consider PBL a gratifying instructional methodology, despite the fact that it takes considerable time and makes it difficult to cover a pre-defined syllabus. Despite these results, it appears that the influence of PBL on teachers' practice has been less examined than its effects on students' training. In fact, Savin-Baden (2000, p. 9) affirms that there is scarce knowledge on PBL in terms of faculty's lived experience and that students' and teachers' voices are "largely missing from the literature on problem-based learning." This is to say that there is limited research on teachers' gains and losses in PBL, beyond enhanced job satisfaction and increased demand of teaching-related time. This gap is what this work attempts to address. It is part of an investigation, in collaboration with an engineering teacher, into the viability of using a partial PBL format (i.e., in single subjects within conventional lecture-based curricula). The focus of this work is the teacher's assessment of PBL as regards his work and its effects on his professional development.

Research Methodology

In accordance with Savin-Baden's (2000) suggestion, a qualitative research design was adopted as it is recommended when the researcher wishes "to make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 1994, p. 4). Moreover, among the possible qualitative research designs, a case study – i.e., "an examination of a specific phenomenon such as a program, an event, a person, a process, an institution, or a social group" (Merriam, 1988, p. 9) – corresponded to the purpose of this work as it is particularly indicated to investigate innovative educational practices and programs (Merriam, 1988). The research project also incorporated some features of collaborative designs, because it intended to assist the participant teacher (hereinafter referred as Teacher) in developing his teacher knowledge base as well as shedding light on this experiment with PBL.

The Teacher, a voluntary participant in the research, was 45 years old and had been teaching at the university (subsequently referred as the University) for over 20 years at the time of data collection. He has a double major in industrial engineering and business administration and a Ph.D. in industrial engineering. The University is a medium-size campus (3,500 undergraduate students and 2,500 graduate students) of a renowned research-university in the State of São Paulo, Brazil. One of the main characteristics of this campus is that it houses only programs in natural and mathematical sciences, the so-called 'hard' sciences.

The research was carried out in three phases. During Phase 1 the researcher and the participant teacher planned the implementation of PBL, i.e., format, problems and assessment of student performance. During this phase the researcher also observed some of the Teacher's classes to get acquainted with him and his teaching methods, the subject matter and the educational context as a whole. In Phase 2 PBL was implemented in four subjects taught by the Teacher covering similar syllabi: General Administration Theory (GAT). The subjects (one 100-minute class per week each) lasting one semester (16 weeks) were offered to civil and production engineering students and to industrial engineering graduate students; in Phase 3 it was offered in the electrical engineering program (all classes having 40-60 students). The data analysed in this work derive from unstructured interviews with the Teacher and participant observations of classes during the three phases. In agreement with the adopted methodological perspective, excerpts of the Teacher's discourse, in italics, illustrate the discussion section of this article.

Implementation of PBL

The PBL process adopted in Phase 2 was similar and based on the aforementioned principles and process (Figure 1). Thirteen problems were presented to the students in total during the semester. As the students had one 100-minute class per week, the class was divided into two segments. In the second half of the class a problem was introduced to self-directed groups of 4-5 students (alternately assuming the roles of leader, spokesperson, scribe and active members), who went on to identify the problem, brainstorm and hypothesize its causes, attempt to solve it with their available knowledge, determine new learning needs, and plan their self-directed work for the following week. During this phase the Teacher acted as a "floating" facilitator, i.e., he went around the class, from group to group, checking their progress, questioning their commonsense/equivocal understanding of the situation in question, and solving doubts about the PBL process. In the first half of the subsequent class, the groups (spokespersons) presented and defended their solutions before the whole class. In order to close the PBL cycle, after their presentations the Teacher commented on the appropriateness of the solutions and formal aspects of the presentations.

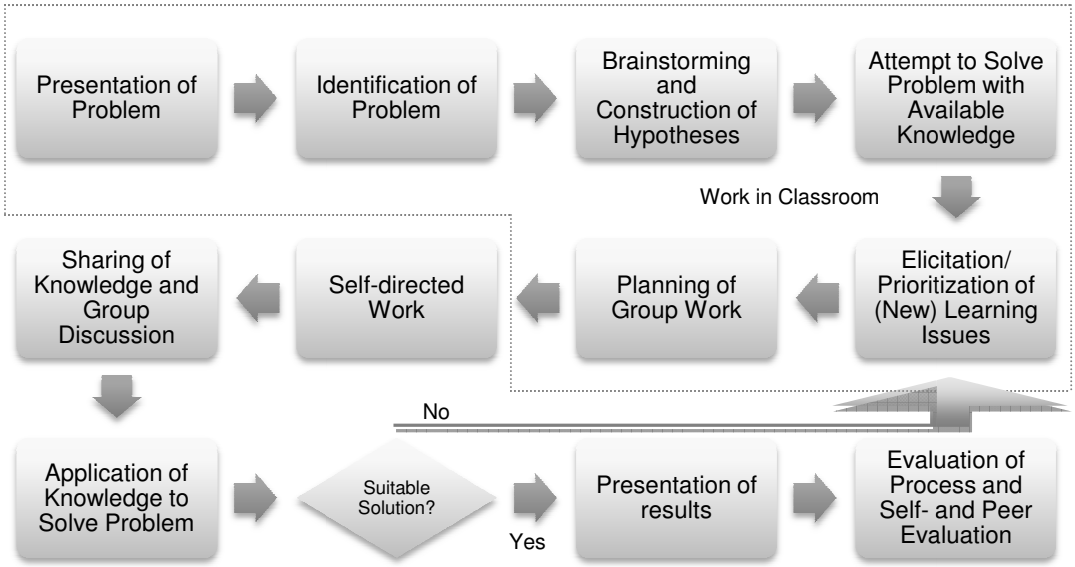

Figure 1: PBL work cycle with a problem in implementation in question.

This PBL implementation employed paper problems, i.e., written narratives of professional dilemmas, to focus and motivate students to learn GAT topics by working in groups, facilitated by the Teacher. Based on Daft (2002), a typical problem given to students is:

> *Comfort is a manufacturer of pre-fabricated houses founded 15 years ago. As most small businesses, it was initially structured around functions. In its first ten years of existence, Comfort developed at a slow pace, but in the subsequent three years it experienced rapid growth. In its 13th year of operation, its president decided to adopt a divisional structure according to the three main lines of houses: luxury, standard and economical. Each division would be run by a director and four (manufacturing, engineering, administrative and commercial) managers. The common services were to serve all divisions, regardless of the division in which they were located. The quality laboratory was one of these services and was located in the luxury division. In the year after restructuring, the laboratory was run by Mr. Rivers, the person who set it up when the company was growing. After Mr. Rivers retired, Mr. Roberts, a civil engineer from the luxury division took control of it. In his first year, Mr. Roberts had many conflicts with Ms. Lewis, an industrial engineer in charge of the economical division. Ms. Lewis complained that Mr. Roberts might be deliberately favouring the engineering section of his division to the detriment of others and that her division's urgent matters were not being addressed properly. In the following year the conflicts became so recurrent that the president of Comfort asked his assistants – you – to look into the problem and propose a solution.*

Results and Discussion

Much of the Teacher's assessment of PBL is in agreement with the literature. To begin with, one of the most cited gains of using PBL – i.e., students' and teachers' satisfaction with the methodology (Albanese and Mitchell, 1993) – was reaffirmed in this study. Like his pupils (Ribeiro & Mizukami, 2005; Ribeiro, 2008), the Teacher appraised PBL favourably. He reported that PBL had corresponded to what he thought should be the mission and goals of higher education and the role of university teachers. He also liked the fact that his teacher role in PBL resembled other academic activities such as researching and advising graduate students, and that this role was somehow capable of reconciling these fundamental and often opposing academic activities. At any rate, the positive evaluation on the part of the Teacher agrees with Huberman (1973), who found greater acceptance of educational changes when they met teachers' specific needs.

The Teacher's age and career phase should be also taken into account when analysing his overall response to PBL. According to Sikes (1985), the Teacher's age at the time fell within the bracket when teachers question what they have done in their lives and careers and seek ways to express themselves and be satisfied in the forthcoming years. On the other hand, Huberman (1995) places the Teacher's years of teaching in a phase of professional experimentation and diversification. In addition, Chamlian (2003) – in her work with innovative higher education teachers – sustains that teachers at more advanced phases of their careers are more free (regarding publication and tenure pressures) to address teaching issues. All these factors may have contributed to his motivation to try PBL and his satisfaction with its implementation.

At any rate, the Teacher also pointed to the capacity of PBL to make teaching and learning *more fun* and his classes more dynamic to the students as well as to himself, which coincides with Albanese and Mitchell's (1993) findings. Furthermore, he said that PBL had made his classes unique, exciting and intellectually challenging:

> *How can teachers teach the same subject through lectures for ten years? What is their motivation? Teachers, too, need to feel motivated! [PBL] motivates in this way: the students always bring up different aspects [about the topic in question].*

This intellectual incentive may contribute to the Teachers' development of content knowledge, consistent with Schön's (1991) and Quinlan's (2003) postulations. Besides, the Teacher's acceptance of PBL illustrates research findings that suggest that successful educational changes should be so constructed and sustained as to make both the intellectual and emotional sides of teachers' work enjoyable and engaging (Hargreaves et al., 2002).

Nonetheless, the Teacher also saw this intellectual challenge as a potential cause of resistance to PBL on the part of faculty because this instructional approach made his classes more unpredictable. Given that some unpredictability is inherent to teaching regardless of the instructional method adopted (Tardif, 2002), the unpredictability caused by PBL appears in the Teacher's discourse in terms of:

- Loss of control related to covering the syllabus: *PBL places the teacher in such a situation... I wouldn't call it bad, but a situation where things can happen much more*

> *freely than in lectures. I could describe teaching in PBL as unpredictable, especially with regard to planning [of classes]*; and

- Vulnerability to unfamiliar topics, raised by students: *[In PBL classes] there are unanticipated issues that you have to sort out on the spot. You've got to deal with topics you hadn't previously thought about. You hadn't expected them to come up and... There! The student catches you! You're cornered!*

Moreover, according to the Teacher, this unpredictability was aggravated by the very nature of the content he taught, since

> *the biology guy [teacher], for instance, will have less external interference from other types of knowledge than those [teachers] who work with business administration theory, because students can come up with self-help, religion...*

The perception of increased unpredictability may be one of the sources of teachers' concerns and resistance to PBL, as it appears that this methodology tests what teachers should know and do. As this has been closely linked to how professionals, in general, conceive their professional identity (Huberman, 1973), PBL may unintentionally bring about uncomfortable psychic feelings and, as a result, resistance on the part of teachers. Indeed, the Teacher's apprehension about being unable to cover the syllabus is a common feeling among PBL teachers (Albanese and Mitchell 1993). Gallagher and Stepien (1998) also ranked this feeling as one of the most cited obstacles, by teachers, to changing classroom practices – a legitimate concern, since cooperative learning approaches, such as PBL, do not prioritize syllabus coverage, but the development of analysis, synthesis, evaluation and critical thinking skills (Herreid, 1998). As a consequence of the prioritization of these higher order thinking skills, Albanese and Mitchell (1993) point to the existence of 'holes' in the conceptual knowledge base of professionals trained via PBL. These conceptual 'holes' are attributed by Herreid (1998) to the unpredictability of PBL, because the content covered in a PBL subject/curriculum is partially determined by the students' interests, and it is difficult to conceive problems that address all concepts and theories proposed by the curriculum. Nonetheless, Herreid (1998) believes it is more important to aim at the development of higher-order thinking skills, since most conceptual knowledge deficiencies may be later remedied by self-directed study, workshops and specialization courses.

In turn, the fear, expressed by the Teacher, of being placed in a situation where he would have to admit to not knowing some concept or fact also appears to be common in PBL. Powell (2000), for example, reports increased teacher vulnerability and states that PBL tests the competence of teachers when students raise unexpected questions or questions whose answers extrapolate their area of expertise. Still, the Teacher's perception of vulnerability may be discussed in light of a combination of institutional, cultural and individual aspects observed at the University during Phase 1. This view may have its origin in the conception – shared by both faculty and students – of teachers' role as knowledge experts and imparters, typical of positivistic educational environments (Menges & Austin, 2001). The Teacher may have also resented this vulnerability because of how the University assessed teacher performance, based on students' end-of-term assessment questionnaires, of which mastery of content knowledge was an important item. Additionally, this feeling may also be attributed to the internalization of an indisputable authority especially on the part of research-university faculty in the fields of 'hard' sciences and technology, such as engineering (Ferraz, 1983). In any case, it is important to remark that the perceptions of loss of

control and vulnerability may prevent or hinder the adoption of PBL because most teachers resist changes that diminish their authority over their classes and pupils (Huberman, 1973). Watson and Groh (2001), for example, advise that it may be difficult for teachers – even for those who believe that a change to PBL is pedagogically sound and desirable – to delegate even a little responsibility for learning to the students.

In addition to greater unpredictability, the Teacher reported an increase in the time devoted to subjects, confirming Albanese and Mitchell's (1993) meta-analysis. According to him, this was due to the need for (re)writing problems, grading reports, writing feedback, computing marks from evaluations (his, the students' self-evaluations and evaluations of peers) and reflecting on the groups' hits and misses to give them oral feedback during the subsequent classes. Notwithstanding, this increase in workload should be relativised, since teachers are, ideally, accountable for most of the aforementioned tasks in whatever instructional approach. Also, the increase in the workload may relate more to aspects of the PBL format adopted in the implementations under consideration (e.g. one problem per week) – which, among other things, ended up producing many evaluations – than to PBL as a whole.

That said, it should be also remarked that not only did PBL consume more of the Teacher's total time, but it also raised, however moderately, the time load in a uniform manner throughout the semester and restrained his autonomy to manage his time. This continual increase was due to the fact that PBL made it difficult to produce a thoroughly anticipated syllabus plan. Despite the planning done in Phase 1, the Teacher had to revise implementation aspects to accomplish the goals of the subjects and to respond to problems and suggestions noted by students in their weekly assessment of the educational process. Therefore, contrary to what is usually implied and criticized about active learning approaches, such as PBL, the Teacher's role did not lose significance. In reality, PBL reshaped the Teacher's practice vis-à-vis the two aspects of teaching described by Tardif (2002), namely, aspects pertaining to the transmission of conceptual knowledge and aspects related to the management of classroom interactions. PBL may reduce the teacher's role concerning the transmission of conceptual knowledge, but it only does so if one confines this aspect to the classroom.

According to the Teacher this teaching aspect was enhanced outside of the classroom, as he spent more time grading reports and devising problems at his office or home. Nor was his role regarding the management of classroom interactions diminished. PBL appeared to challenge the Teacher's leadership skills in the supervision of the educational process and students' actions, to motivate students and resolve conflicts within groups. The increase in the Teacher's workload due to this constant (re)planning of PBL cycles (problems, time allocated to cycle segments, etc.) and conscientious marking of – and writing feedback on – his students' reports was confirmed by observation in Phase 3. In this PBL implementation, instead of marking the reports himself as he did in Phase 2, the Teacher assigned this task to a graduate student.

Besides increasing the Teacher's time devoted to teaching, planning for PBL classes appears to have been different from the way he used to plan his subjects and prepare his classes. For instance, he had planned all his Phase 1 classes during the preceding school vacation. What is more, it was observed that PBL disagreed with the *modus operandi* of the University. At the University, as in most school bureaucracies (Thurler, 2001), the managerial parameters were determined before the beginning of the semester/year; then, it was supposed to run by itself – with just minor adjustments – until the following vacation. In addition, this constant planning seemed to hinder 'routinisation' (Giddens cited by Tardif, 2000), i.e., the reduction of teaching-related situations to regular action

schemes, which, for instance would allow the Teacher to focus on more valued activities, such as research.

Likewise, PBL appears to have restricted the Teacher's ability to manage his extra-class time. PBL made it difficult for him to postpone tasks, such as planning and marking students' reports, and conflicted with aspects external to teaching, including academic commitments such as participation in congresses, which could be more easily accommodated in conventional teaching models. This may be illustrated by an episode that took place in Phase 2. The Teacher, taking advantage of his undergraduate students' spring recess, proposed to his graduate students to have two classes on the same day. He seemed to wish to abridge the graduate program, thus alleviating both his workload at the end of the semester and the out-of-town students' need to commute. Obviously, after some pondering the Teacher and students agreed that it was not feasible because the students would have no time to do research and write reports. Furthermore, although the Teacher never missed any classes during data collection, it may be assumed that a substitution would have been more disruptive in PBL than in lecture-based methods, in which teachers can be readily substituted by stand-by teachers, by communication media or by individual reading of texts.

The effects of PBL on the Teacher's time/workload confirm the importance ascribed to this aspect in PBL implementations (Cavanaugh, 2001). Much more so in the context of research universities, where other activities of faculty include more valued and rewarding activities for career advancement (e.g., research, participation in congresses and committees and advising graduate students). This aspect is particularly relevant because it seems that the critical factor for success of any educational innovation, as suggested by Huberman (1973), is not its nature or what it can do to promote students' learning, but how teachers perceive the personal changes they will have to make.

Despite these effects and the short duration of the implementations in Phase 2 (16 weeks), the PBL format adopted seems to have contributed to the Teacher's professional development by changing some conceptions about teaching. This was attested by the fact that he utilized one problem every two weeks in Phase 3, showing less concern for complete coverage of the syllabus. In addition, PBL appears to have fostered the Teacher's reflective process, as defined by Schön (1983), enhanced by the fact that he had employed it in three concurrent subjects:

> *I think I'll learn how to use the method [PBL] quickly, since I'm implementing it in three subjects. Look at the example of the problem that was modified overnight!*

This process of reflection also led the Teacher to change other aspects of the methodology several times including the format of students' reports to meet his observations of the students' performance and respond to their feedback.

Furthermore, as previously attested by Palmer and Major (2007), PBL seems to have advanced the development of many components of the Teacher's teacher knowledge base, as described by Shulman (1987). The need to restructure the syllabus around problems, establish subject goals beyond the acquisition of conceptual knowledge encouraged him to reflect on the curriculum, the program and the national guidelines for engineering curricula. In fact, it has been reported that designing a subject or curriculum constitutes an important learning opportunity for teachers and can be a powerful mode of professional development (Quinlan, 2003). In addition, it was observed

that the conflicts arising from attempting to harmonize the requirements of PBL with the characteristics of the University also assisted the Teacher in the development of other knowledge essential to teaching.

Chief PBL activities (e.g., students' assessment tasks and reports, group presentations of solutions and classroom discussions) may foster teachers' knowledge of students. The Teacher reported that these activities stimulated his understanding of his pupils' interests:

> *I think that PBL helps one to know one's pupils: their inclinations and intentions. […]; what interested them most; what they would like to see; what drew their attention…*

Likewise, PBL appears also to promote teachers' understanding of how students think. As regards his students' cognitive processes, the Teacher reported that *PBL allows one to see how students process information, their reasoning process, possibly. Not in a very strict sense, but their reasoning in a broader sense. One can see how students perceive organizations, how they express their values.*

An increased understanding of students' interests and reasoning is one of the greatest gains of working with PBL. This knowledge can be positively combined with the content knowledge to develop the pedagogical content knowledge (Shulman, 1987). Indeed, there is some evidence that the Teacher's pedagogical content knowledge appears to have been strengthened in this period:

> *I think that the skills mentioned by the [PBL] authors are very general, pertaining to general cognitive processes. However, what are the specific skills needed by students to learn about organizations? Maybe they are not that different, but they will certainly emphasize this or that*. To which the Teacher added: *From now on, I'll keep my eyes open to the skills and group dynamics that suit the organizational theory. Obviously, I think there's a common ground, a process common to all [disciplines], but [it varies] according to their content, right?*"

The above excerpt also shows a desirable effect of PBL on the Teacher's development: PBL fostered his interest in learning more about teaching. Other excerpts corroborate this gain:

> *I became aware of these things just this semester. I'll have to read a little about skills, especially skills that suit the organizational theory. From now on I'll be open to that, because that's probably gone unnoticed*.

This is a particularly promising result in the context of the University, which hires teachers with no pedagogical training and does not offer in-service teacher training. However, the Teacher's disposition to continue learning about teaching seems to be more directed to improving his practice than to becoming an expert in pedagogy:

> *I spent twenty years focused on [conceptual] knowledge. I mean, what this method [PBL] will help me think about... I'll probably have to become... maybe not an expert as I am in administration theory, but I'll have to have good knowledge about skills.*

This is in accordance with Tardif (2002), who claims that teachers do not want to learn about pedagogy just for the sake of knowing it, but to act and do; what they seek to know is how to be better professionals.

Concluding Remarks

Despite obstacles found in this experience with PBL and the losses perceived by the Teacher (e.g., reduced control over content coverage, increased vulnerability and teaching-related workload), the data suggest that the PBL format adopted in the intervention contributed to the Teacher's professional development, a result that has been little explored by investigators. This is a significant gain given the fact that many university teachers come directly from baccalaureates and graduate programs with little or no pedagogic content, and their entrance and progress in the institutions are based more on their research accomplishments than on their teaching performance.

Although it is difficult to generalize from a case study, the activities found in this and other PBL formats – including process assessment tasks done by students and a larger number of opportunities to assess students' performance – seem to encourage teachers' constant reflection on their teaching practice, which can lead to perceive the need for continual improvement. In this sense, even though it cannot replace a teacher's initial and continuing pedagogic education nor address the complexity of teacher education, PBL can be a catalyst in university teachers' professional development.

The results of this study also indicate that PBL may be a valuable tool in the investigation of teachers' values, conceptions and practices. This is so because PBL brings about unexpected classroom situations, poses teaching dilemmas and stimulates decision-making as to the best strategies to help students learn the content as well as develop professionally and socially desirable skills and attitudes. Above and beyond, the most significant gain deriving from the use of PBL is, perhaps, its capacity to confer a fresh zest to the teaching-learning process, for teachers and students alike, even in partial implementations of the methodology, as acknowledged by the Teacher:

> *The gain was in terms of [class] dynamics, participation, free thinking... all what we imagine education should be about. I think freedom is a very important issue […]. Then I see a system like this, when you use PBL in an isolated subject, whose students have been schooled in another system [lecture-based] for eleven, fifteen years... How wonderful it is to see them [students] working by themselves! I think that it was often inspiring... I was impressed by the sight of some groups discussing the problem with determination, in depth. I could see they weren't kidding... What better learning is there than five people discussing a problem at great length, even with passion? I witnessed them defending their points of view... earnestly! They weren't fooling around! Man is free to express his opinion... I mean, I think that the fact that PBL was capable of provoking that really touched me!*

References

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: a review of literature on its outcomes and implementation issues. *Academic Medicine,* 68(1), 52-81.

Barrows, H. S. (2001). *Problem-based learning (PBL)*. Retrieved June 16, 2001, from Southern Illinois University PBL Web site: http://www.pbli.org/pbl.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: a brief overview. In L. Wilkerson, & W. H. Gijselaers (Eds.), *Bringing problem-based learning to higher education: theory and practice* (pp. 3-12). San Francisco, CA: Jossey-Bass.

Bok, D. (1986). *Ensino superior*. Rio de Janeiro, RJ, Brazil: Editora Forense-Universitária.

Candau, V. M. F. (1996). Formação continuada de professores: tendências atuais. In A. M. R. Reali, & M. G. N. Mizukami (Eds.), *Formação de professores: tendências atuais* (pp. 139-152). São Carlos, SP, Brazil: EdUFSCar/FINEP.

Cavanaugh, J. C. (2001). Make it so: administrative support of problem-based learning. In B. J. Duch et al. (Eds.), *The power of problem-based learning* (pp. 27-36). Sterling, VA: Stylus, 69-68.

Chamlian, H. C. (2003). Docência na universidade: professores inovadores na USP. *Cadernos de Pesquisa, 118*, 41-64.

Daft, R.L. *Organizações, teoria e projeto*. São Paulo, SP, Brazil: Thomson, 2003.

Delors, J. (1999). *Educação: um tesouro a descobrir*. São Paulo, SP, Brazil: Cortez/UNESCO.

Deming, W. E. (1986). *Out of the crisis*. Cambridge, MA: MIT Press.

Denzin, N. K., & Lincoln, Y. S. (1994). Entering the field of qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 1-17). Thousand Oaks, CA: Sage.

Dochy, F. et al. (2003). Effects of problem-based learning: a meta-analysis. *Learning and Instruction, 3*, 533-568.

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). *The power of problem-based learning*. Sterling, VA: Styllus.

Ferraz, H. (1983). *A formação do engenheiro: um questionamento humanístico.* São Paulo, SP, Brazil: Ática.

Gallagher, S. A., & Stepien, W. J. (1998). Content acquisition in problem-based learning: depth versus breadth in American Studies. In R. Fogarty (Ed.), *Problem-based learning: a collection of articles* (pp. 51-71), Arlington Heights, IL: Skylight.

Gijselaers, W. H. (1996). Connecting problem-based practices with educational theory. In L. Wilkerson, & W. H. Gijselaers (Eds.), *Bringing problem-based learning to higher education: theory and practice* (pp. 13-21). San Francisco, CA: Jossey-Bass.

Hargreaves, A., Earl, L., Moore, S., & Manning, S. (2002). *Aprendendo a mudar: o ensino para além dos conteúdos e da padronização*. Porto Alegre, RS, Brazil: Artmed.

Herreid, C. F. (1998). Why isn't cooperative learning used to teach science? *BioScience, 48*(7), 553-559.

Huberman, M. (1973). *Como se realizam as mudanças em educação: subsídios para o estudo do problema da inovação*. São Paulo, SP, Brazil: Cultrix.

Huberman, M. (1995). O ciclo de vida profissional dos professores. In A. Nóvoa (Ed.), *Vidas de professores* (pp. 31-61). Oporto, Portugal: Porto Editora.

Kingsland, A. (1993). Problem-based learning: efficient, affordable, and stress-free implementation. In G. Ryan, G. (Ed.), *Research and development in problem-based learning – Volume 1* (pp. 311-319). Sydney, NSW, Australia: University of Sydney-MacArthur Press.

Marcelo Garcia, C. (1992). Formação de professores: centro de atenção e pedra-de-toque. In A. Nóvoa A. (ed.), *Os professores e a sua formação* (pp. 51-76). Lisbon, Portugal: Dom Quixote.

Menges, R. J., & Austin, A. E. (2001). Teaching in higher education. In V. Richardson (Ed.), *Handbook of research on teaching* (pp. 1122-1156). Washington, DC: AERA.

Merriam, S. B. (1988). *Case study research in education: a qualitative approach*. San Francisco, CA: Jossey-Bass.

Mizukami, M. G. N. et al. (2002). *Aprendizagem da Docência: Pesquisas e Especificidades Metodológicas*. São Carlos, SP, Brazil: EdUFSCar.

Ning, C. C. (1995). Undergraduate academic programme: planning, development, implementation and evaluation. *International Journal of Engineering Education,* 11(3), 175-184.

Palmer, B., & Major, C. (2007). Engendering the scholarship of problem-based learning. *International Journal for the Scholarship of Teaching and Learning 1*(2). Web site: http://www.georgiasouthern.edu/ijsotl.

Powell, P. (2000). From classical to project-led education. In A. S. Pouzada (Ed.), *Project-based learning: project-led education and group learning* (pp. 11-40). Guimarães, Portugal: Editora da Universidade do Minho.

Quinlan, K. M. (2003). Effects of problem-based learning curricula on faculty learning: new lenses, new questions. *Advances in Health Sciences Education, 8*, 249-259.

Regehr, G., & Norman, G. R. (1996). Issues in cognitive psychology: implications for professional education. *Academic Medicine,* 71(9), 988-1001.

Ribeiro, L. R. C. (2008). Electrical engineering students evaluate problem-based learning (PBL). *International Journal of Electrical Engineering Education,* 45(2), 153-161.

Ribeiro, L. R. C., & Mizukami, M. G. N. (2005). Problem-based learning: a student evaluation of an implementation in postgraduate engineering education. *European Journal of Engineering Education,* 30(1), 137-149.

Savery, J. R., & Duffy, T. M. (1998). Problem-based learning: an instructional model and is constructivist framework. In R. Fogarty (Ed.), *Problem-based learning: a collection of articles* (pp. 72-92). Arlington Heights, IL: Skylight.

Savin-Baden, M. (2000). *Problem-based Learning in Higher Education: Untold Stories.* Buckingham, UK: Open University Press.

Schmidt, H. G. (1993). Foundations of problem-based learning: some explanatory notes. *Medical Education, 27*, 422-432.

Schön, D. A. (1983). *The reflective practitioner: how professionals think in action*. New York, NY: Harper Collins.

Schön, D. A. (1991). *Educating the reflective practitioner.* San Francisco, CA: Jossey-Bass.

Shulman, L. S. (1987). Knowledge and teaching: foundations of the new reform. *Educational Review, 57*(1), 1-22.

Sikes, P. J. (1985). The life cycle of the teacher. In S. J. Ball, & I. F. Goodson (Eds.), *Teachers' lives and careers* (pp.27-60). London, UK: The Falmer Press.

Stinson, J. E., & Milter, R. G. (1996). Problem-based learning in business administration education: curriculum design and implementation issues. In L. Wilkerson, & W. H. Gijselaers (Eds.), *Bringing problem-based learning to higher education: theory and practice* (pp.33-42). San Francisco, CA: Jossey-Bass.

Tardif, M. (2002). *Saberes Docentes e Formação Profissional.* Petrópolis, RJ, Brazil: Vozes.

Thurler, M. G. (2001). *Inovar no Interior da Escola*. Porto Alegre, RS, Brazil: Artmed.

Tynjälä, P. (1999). Towards expert knowledge? A comparison between a constructivist and a traditional learning environment in the university. *International Journal of Educational Research, 31*, 357-442.

Vasilca, G. (1994). Engineers for a new age: how should we train them? *International Journal of Engineering Education, 10*(5), 394-400.

Vernon, D. T. A., & Blake, R. L. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine, 68*(7), 550-563.

Watson, G. H., & Groh, S. E. (2001). Faculty mentoring faculty. In Duch, B. J. et al. (Eds.), *The power of problem-based learning* (pp. 13-25). Sterling, VA: Stylus.

Woods, D. R. (1996). Problem-based learning for large classes in chemical engineering. In L. Wilkerson, & W. H. Gijselaers (Eds.), *Bringing problem-based learning to higher education: theory and practice* (pp. 91-99). San Francisco, CA: Jossey-Bass.

Zabala, A. (1998). *A Prática Educativa: Como Ensinar*. Porto Alegre, RS, Brazil: Artmed.

Zeichner, K. M. (2000). Para além da divisão entre professor-pesquisador e pesquisador acadêmico. In C. M. G. Geraldi et al. (Eds.), *Cartografias do trabalho docente: professor(a)-pesquisador(a)* (pp. 207-236). Campinas, SP, Brazil: Mercado de Letras.