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SPECIAL ISSUE ON COMPETENCY ORIENTATION IN PROBLEM-BASED LEARNING:
VOICES FROM THE FIELD

Getting Started With PBL—A Reflection

Tanja Müller and Thomas Henning (City University of Applied Sciences Bremen)

Abstract

In this paper, we provide insight into the PBL project called PoLiMINT (Problem-oriented Learning in MINT). The project is located at the Bremen University of Applied Sciences and aims to introduce and foster PBL in the introductory phase of a physics study program. Concerning our general conditions, we will present our incremental implementation strategy and address the first elementary steps. In order to demonstrate our Scholarship of Teaching and Learning mode of reflecting the implementation process, we examine selected instructional and pedagogical difficulties and our problem-solving more closely.

Keywords: incremental strategy, solving implementation problems, Scholarship of Teaching and Learning in PBL, seven steps, introduction, physics courses, problem representations

PoLiMINT: Objective and Background

PoLiMINT is an acronym for Problem-oriented Learning in MINT (mathematics, information science, natural science, and technology), which is comparable in English to problem-based learning in STEM (science, technology, engineering, and mathematics). It represents two meanings: the name of a project at the University of Applied Sciences in Bremen, Germany, and, simultaneously, the purpose of fostering PBL in MINT-degree courses, because most teaching has been done in a traditional teacher-centered way, through lectures and laboratory work.

The project is located in the faculty of electrical engineering and information science, but it is not a top-down project. It focuses on the international studies in engineering and applied physics bachelor's program. Although the professors have extensive teaching experience, they previously had no experience with PBL apart from reading the literature. Funding provided the opportunity to employ a research and teaching associate, who collaborated with the lecturers to get the change started. As long as she, namely the first author, was an expert in social sciences and PBL, there was no classical expert-novice constellation but instead a very productive interdisciplinary team.

The overarching aim of the project was to introduce PBL in at least two courses in each semester of the study program's introductory phase; that is, to determine how PBL could fit best into the given situation and framework. The project started in March of 2014, so we are able to report on our first two years "getting started with PBL" and the obstacles we faced. But first of all, we want give a short introduction about what we refer to when we talk about PBL.

Core Elements of PBL

A considerable amount of literature has been published on PBL. Three recurring questions can be identified: The first one is about the quality and characteristics of problems, as they are the starting point in a PBL learning cycle and its theoretical background (e.g., Duch, 2001; Maufette, Kandlbinder, & Soucisse, 2004). The second question draws attention to the effectiveness and efficiency of PBL compared to other classroom settings (e.g., Küng, Scholkmann, & Ingrisani, 2012; Müller, 2007). The third and one of the biggest issues concerns the introduction of PBL. On this issue, you can find case studies (e.g., Duch et al., 2001) as well as publications that focus on and analyze the implementation process on a more theoretical level (e.g., Kolmos, de Graaf, & Du, 2009).

The literature also gives a broad range of different models and types of PBL associated with various educational

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objectives (Kolmos et al., 2009; Savin Baden & Major, 2004). Despite such a variety across PBL, there is some agreement on what is meant by a PBL learning environment. Because in PoLiMINT we refer to this common ground, the core elements are outlined here briefly: According to Newman (2005), there are at least four characteristic elements in organizing a PBL learning environment: (1) learning and teaching practices are organized around problems, with a problematic case as the starting point for any further learning; (2) such a case will be discussed and analyzed by a small group of students; (3) to stimulate self-regulated learning as an important element in the working process, the students are responsible for themselves and a tutor only facilitates during sessions; (4) finally, there needs to be an appropriate assessment.

But to implement PBL in classrooms means more than applying only a method or listing the technical characteristics. As Bouhuijs (2011) argues, it also demands a minimum of changes in the organizational structure and culture. Managing such an implementation depends on strategic decisions, educational objectives, and very much on the resources available.

An Incremental Implementation Strategy

To clarify what is meant by "implementation" in our case, we want to look at the issue a bit more closely. Two topics are discussed especially frequently in the PBL field. While the first one focuses on the different levels of implementation, the second one looks at the obstacles or challenges that influence an implementation process.

Regarding the first point: From a general perspective, implementation can be carried out on either a course or a system level (Kolmos et al. 2009, p. 19). The course approach deals with a combination of PBL courses and traditional ones. Usually, it is set up by teachers themselves, and they decide how to combine different modes and methods and determine the assessment. In contrast to this, the system approach is necessarily organized using a top-down strategy to successfully define PBL as an extensive strategy that dominates the entire curriculum and is part of the department's educational model. As the history of PBL and the development of institutions of higher education shows, most of the time PBL as a full curricular program has only been implemented at newly founded universities or colleges (Bouhuijs, 2011). Whether a system or a course approach is used, one needs to solve the problems that occur during the transition, otherwise PBL will not remain sustainable, as de Graaff (2008) illustrates.

In order to solve such problems and sustain PBL, our strategic approach is best described as incremental. It is neither top-down, nor bottom-up, but characterized by continuous processing decisions in very small steps. It requires constant reflection on and improvement of what we are doing. We did not assume to know what PBL program meshed best with the existing study program, or how the personnel and financial resources fit with PBL conditions, so we started by creating a PBL practice to gain more information. In order to adjust the existing teaching structures to PBL and to adapt PBL in at least two courses in the first semester, we needed to observe its practical implications in real-life scenarios, because improvement can only happen when there are problems identified.

Getting Started With PBL Means Getting Into Practice

As we have seen, to stick to a stepwise improvement of PBL in PoLiMINT, it is essential to start at a chosen point and create an arena or space of PBL practice for experience-based learning. One of our assumptions regarded challenges in and questions about implementing PBL: that they cannot be solved through theory—improvements have to be discovered through practical application.

We started setting up a PoLiMINT-Lab (Müller & Henning, 2015) in advanced studies courses. By using a regular advanced study course, professors immediately got involved in experimenting with and reflecting on social dynamics in PBL group discussions. Because the lab semantics were familiar to the science teachers, less explanation was necessary and the lab seemed much more tolerant to errors and failures.

As in any experimental work in a laboratory, the systematic observation and evaluation of presuppositions is elementary. In the lab, our work focused on the preparation and development of appropriate PBL learning environments. Then, we proceeded with PBL sessions and reflected on the processes and outcomes afterward.

Since we do not have many resources for extensive associated research, we decided to use the analytical potential of the Scholarship of Teaching and Learning (SOTL; Kreber & Cranton, 2000). It provides a solid basis for systematic reflection on the teaching process in higher education, and is introduced briefly in the next section.

SOTL as an Instrument for Reflecting on Our Practice

Without a doubt, teaching and learning benefit from reflecting on these practices. Using some sort of theoretical consideration is very useful for reflection; in order to sharpen the analytical perspective on PBL as a new strategy in the teaching and learning culture, only reading literature is not sufficient. In addition, not only was an academic reflection scheme needed, but also something that could serve as a reflecting tool for teachers. The Scholarship of Teaching and Learning concept met these criteria. Introduced in the early 1990s, it was refined by Kreber and Cranton (2000). According to them, and based on the transformative learning theory of Mezirow (1991), teachers are seen as adult learners whose "knowledge is constructed through three different levels of reflection—content, process and premise" (Kreber & Cranton, 2000, p. 478). The first reflecting domain corresponds to the extent of instructional knowledge, such as knowing how to introduce and organize different methods in class. The second domain's focus is reflecting on the process according to pedagogical knowledge. Working with learners always demonstrates how important it is to understand how learning can be fostered—for such a matter, not only formal theories of learning, but implicit concepts are also significant. Knowing how to facilitate discussions among students and encourage their collaboration is one example that can illustrate that pedagogical knowledge. The third domain is called "reflecting on premises" and is related to curricular knowledge. Kreber and Cranton (2000, p. 480) draw attention to the way "we question the merit and functional relevance of teaching." The scheme helped raise generative questions concerning PBL implementation and our incremental strategy, which focused on the improvement of what we identified as a problem or barrier.

In order to develop our Scholarship in Teaching and Learning with PBL, we collected materials in the PoLiMINT-LAB to help us reflect on, for instance, our instructional materials or pedagogical expertise. These materials included observations of small group discussions, exploratory interviews with tutors and students, or photographs of the whiteboard that documented the discussion outcomes. Furthermore, we used an online forum to discuss drafts of new cases for problems and continued to discuss relevant problems before and shortly after PBL sessions. So far focusing on the reflection framework, the following section will outline and discuss some crucial problems and the consequences and conclusions we drew.

Reflection on Our Implementation Practice

The most notable problems at the very beginning of our incremental process we faced were in the domains of instructional and pedagogical knowledge. First, one problem concerns the interdependence between teachers and teaching objectives, meaning the teaching culture of working with teaching content—in our case, the PBL problems and how to prepare them. Second, another issue relates more to the practice of facilitating students' work in PBL. Turning now to four selected points, we want to illustrate some problems we have been confronted with and how we improved and changed our PBL practice in an incremental way.

The "Problem" With the PBL Problems

The first major problem occurred while we were trying to find and develop appropriate PBL problems. We expected this difficulty, and we faced it as soon as we started preparing cases for the first PBL lessons.

PBL literature gives plenty of information about the problem criteria. Problems should be ill-defined and therefore complex enough for different solutions. PBL problems should be authentic, and the core of a problem can be described by representing a dilemma or paradox (Raine & Symons, 2005) that needs to be solved. In our psychological research, we went through the crucial points between well-defined and ill-defined problems (Jonassen, 2011). To become aware of all this was one important step, but developing our own PBL learning environments was something entirely different. The written problem drafts seemed to end up with instructions and tasks. Faced with this challenge, we got involved in discourse about what is meant by a "problem," what profound representations the word activates for teachers in their scientific language, and, finally, how they get used to it through professional socialization. The critical point was the problem concept itself. When teachers did not think in terms of well- and ill-defined problems, they remained challenged by the problem concept itself; their implicit theories and representations of problems were extremely task-oriented. Exercises contained many physical or mathematical problems that needed to be solved in class. As Allen, Duch, and Groh (1996, p. 47) describe it: "The traditional end-of-chapter exercises found in most texts are narrowly focused on a chapter topic, and many times encourage students to pattern-match or plug-and-chug in search of *the* correct answer." Task-oriented instructions—such as "Calculate the kinetic energy of the ball at the base of the inclined plane" or "Up to which height does the ball roll up the inclined plane?"—had previously been an integral part of problems in class.

Moreover, since from a teacher's point of view students were not able to solve these sorts of problems easily, and because of their earlier in-class experience, teachers assumed that working with much more open and complex problems could require far too many problem-solving competencies. Understanding this matter was a very important step. In addition, teachers noticed their own levels of insecurity in the instructional knowledge domain, because there was only little experience in knowing how to facilitate exercises when there was no clear right or wrong answer but only a heuristic model, the seven steps, to deal with in teaching.

What did we do to support a conceptual change concerning the understanding of the different nature of problems? Taking a closer look at professional teaching language and teachers' assumptions was an essential point at the beginning of our process, the main part being identifying the deeper learning difficulty. In order to improve the development of PBL problems it was therefore most significant to raise awareness for the ambiguous problem representations, their characteristics, and their consequences in practice.

Second, even adult learners are novices at some point when they are new to something. This was clearly the case with PBL. So we took this matter into account when we set up clear rules, knowing that novice learners are usually looking for clear rules or patterns. We assumed that clear standards may help facilitate new experiences and foster some conceptual change in dealing with the problems. In order to do so we got rid of the previous task-oriented mode and renounced any instructions. In terms of practicing new problems, such texts should be given a narrative structure, with a brief storyline. They should not look like tasks with given information, and should not include instruction at the end. We developed problems as written text materials in a dialogue manner, tested them in the PoliMINT-Lab, and then did some modification afterward, as necessary. Furthermore, in the PoLiMINT-Lab, we arranged to test different variations of one and the same case, meaning with and without instruction. From this experience-based perspective, we could see there is immense productive creativity in problem-solving when dealing with ambiguity.

Four Instead of Seven Steps

We expected to face difficulties when getting involved with PBL problems and managing the shift from a traditional task and instruction orientation to a PBL perspective. In contrast, we did not expect to face difficulties working with the Seven Steps or Seven Jump Scheme. The Maastricht model of the seven steps is the most well-known technique to organize the problem analyzing process in a group discussion (Savin-Baden, 2007, p. 17). In the PBL literature, the labeling and structural elements of these analytical steps seem broadly taken for granted; they are as follows:

1. Clarify unclear terms and concepts
2. Define the problem
3. Analyze the problem in a brainstorming session
4. Arrange explanations and possible solutions
5. Generate learning objectives
6. Study on your own to find answers
7. Synthesize new information and draw back to the problem

Because this outline is short and simple, it seems easy to apply, especially to novices in PBL; this is probably why it is used as an integral part of introductions to PBL (e.g. Weber, 2007). However, difficulties during practice are rarely addressed, so of course, we started organizing the discussion sessions around the steps. But teachers got frustrated because students did not spend much time analyzing the problem situation. Our materials documented what we observed: As the second PBL step forced students to define the problem, students did not take the proper time for further analyses but started producing solutions. Students themselves started getting confused and discussing the logic of the very detailed steps, to the point that they got distracted from the content. Of course, these are problems that may occur when someone is new to a method and needs to get familiarized with it. But after these problems continued over some PBL sessions, we decided to have a closer look and try some changes. First of all, we wanted students to focus much more on analyzing the outlined situation. Second, complexity should rather be a characteristic of the problem itself but not the main aspect of the formal PBL structure to our students, who were carefully trying not to miss anything and complete the steps. For this purpose, we decided to reduce the PBL steps to a very simple scheme containing four elements:

1. What is known about the case (due to information in the text, or because of prior knowledge)? What is not known (because there is information missing or there is no knowledge about it)?
2. Taking all this information into account, what may be the problem(s)? What are the needed tasks to solve it?
3. Study on your own.
4. Synthesize found knowledge in your group and present possible problem-solving strategies.

The first two steps were especially important, as we focused on analyzing information and knowledge, the given and the not given. Students were forced to take a closer look before getting a notion of what they think might be a problem(s). For better orientation, we gave leading questions to the students. The definition of a problem should always be given as a question to prove if everyone in the discussion group is able to identify with it. But much more important: Having a (research) question—instead of a problem statement itself—tends to lead students to search for an answer as a proper guideline.

Facilitation and Teaching Habits—Or 'Where Are You Now'

According to the concept of SoTL, our third critical point is related more to pedagogical knowledge; that is, knowing what facilitates a good discussion in a problem-based learning process. The effectiveness of PBL depends in part on the quality of discussion among students and their interaction with tutors. As much work is based on these communications, two of the main influencing factors we therefore worked on first were the aforementioned four (or conventional seven) steps as a meta-technique to structure the problem analyzing and solving procedure and the modality of the intervention of tutors.

It is known that the behavior of the tutor is dependent on pedagogical attitudes and beliefs toward teaching and learning (e.g. Wilkie, 2004). More precisely, it refers to the degree of autonomy and control a tutor is able to transfer to students' responsibility. Knowing PBL is a student-centered approach means one thing, but to adjust a teaching habit to facilitation practice is another issue, which requires professional adjustment and development. For teachers as tutors, that meant reflecting their present facilitating habits and checking whether or not they were helpful.

For example, after reducing the steps from seven to four, we could recognize that the students improved in their discussions. They could focus much more on content and arguments than on PBL steps and seemed therefore more self-sufficient and efficient. Nevertheless, during our debriefings and based on the evidence of our observation materials, it became obvious that a second factor hindered better communication. Tutors' methods of intervening were not fostering the dynamic of discussion but mainly drawing attention back to them as teachers, not tutors. We have found two elements to work on: First, frequent interruptions discouraged students from talking openly to each other. Moreover, the way the tutor intervened is important to take into account. Sometimes teachers' interest was limited to only checking whether students were progressing in their discussion process or not (e.g., asking "Where are you now?"). Such an interrogative approach undermines the autonomy of the students.

In our reflection on this matter, we were able to explore another persistent professional practice. As teachers were accustomed to solving their tasks in a very strict sequential way, they expected the discussion to work best the same way, especially because there were new guidelines with these four elements (see section above). Certainly, to get straight from one step to the next, one demonstrates some level of expertise in a field. But discussions among students, who are new to a problem (problem novices) do not work straightforward most of the time. Teachers proved to have a distinct pattern of order, and while listening to the discussions it seemed to be somewhat chaotic to them. Also, at the beginning, there was a lack of proper questioning strategies because of a very traditional explaining culture. Getting familiar with facilitation, as a tutor, requires experimenting with new question strategies. So how did we cope with that? Despite the fact that this facilitation development takes time, and therefore exercising and reflecting on a practice, we first gave examples of how to communicate on a meta-level. Second, we illustrated what happens if someone often interrupts a discussion on a formal level. Furthermore, we found some helpful regulation to cope with the uncertainty and chaotic dimension of communication during PBL processes, such as discussion with different people from different points of view. So, finally, we said the important point is that all relevant information can be found in proper order on the whiteboard. This represents an important standard by which teachers as tutors should decide whether it is wise to question the group or let them be, because thinking and communication processes do not follow a strict sequential logic and therefore should not be treated that way.

How Much PBL is Good or Necessary?

How much PBL should be done in a degree course depends on a variety of matters, such as management objectives, educational backgrounds, resources, time capacities, and PBL expertise. In our case, one of the main tasks was to fit PBL into the prevailing structures, such as an existing curriculum and module schedule or timetable. At the same time, our aim was to adjust the structure to PBL requirements. To find what PBL practice matched best, we changed the quantity of problems and the time spent on problems students were dealing with in the courses. This alternation was carried out in the first two years of the project. Due to changes in teaching staff and resources available, we are far from conducting an ideal version. But as far as we can sum up in our reflection, we have observed that time spent on a problem and problem-solving is more valuable than the amount of problem cases in one course. So we decided to include two problems instead of seven, each one taking three weeks' time. This means more or less half of the semester is spent with PBL. Students and teachers have positively received this version so far. But following our incremental strategy, which means constantly reflecting on the process and our curricular knowledge—for instance if we achieve the goals set out in PoLiMINT or not—we must say this still remains an open question. For the time being, our strategy includes taking small steps so that teachers and students are able to get increasingly more involved and experienced with PBL, in order to make further decisions about how much PBL is effective and necessary.

Conclusion

The purpose of this article was to give some information on PoLiMINT in Bremen and to demonstrate the way we are implementing PBL step-by-step. For those new to PBL, it is like a brand new innovation, so the introduction should be treated as such, meaning that teachers and students need to get familiar with the new cultural aspects and demands on thinking about teaching and learning. We developed our PoliMINT-Lab to explore difficulties by reflecting on them, asking questions such as what do we know is the problem here? By carefully examining our observations and adjusting some PBL elements, we could continue to improve. In a metaphorical sense, we got involved with the "magic that dwells in each beginning" (Hermann Hesse), pursued emerging difficulties and experimented with solutions, and gained more Scholarship in Teaching and Learning PBL.

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