

Learning Lab - teaching experienced engineering students PBL

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Abstract: *A new program, Medialogy within the technical faculty at Aalborg University was confronted with the problem that their 6th semester students didn't have enough knowledge about Problem Based Learning (PBL) so they could use the approach to structure their projects. Furthermore Medialogy is an interdisciplinary program combining technical subjects with humanistic subjects so the need for methodological knowledge and training was obvious. To solve the problem a workshop – a learning lab – was established, with the aim to teach and train the methods connected to PBL and establish awareness of the importance of a coherent methodology and the use of theory of science. The workshop was aimed at the students as well as the teachers. The paper describes the workshop as well as the outcome for the students and the teachers. The immediate result was that students in a very convincing way could build upon their previous experience, and from there using the PBL approach to start their problem analysis. The students show excellent work concerning problem formulation, structuring their learning and their conscious use of methods. The results for the teachers were a common understanding of PBL and a mutual interest in each other's research and teaching areas.*

Introduction

Since the start of Aalborg University in 1974 the Problem Based and Project Organized Learning approach has been used and the pedagogical methods have been discussed and developed (Busk Kofoed and Kolmos 2001). As the educations within engineering and science represent almost half of the student intake of the university, special focus has been placed on these educations. During the last decade a consensus has been achieved considering teaching engineering and science students according to the PBL methodology. This training has been introduced to students during their first year in university, and has proven to be both a challenge and a success (Kofoed et al 2004).

An additional pedagogical challenge has been to propose this educational paradigm in the development of new curricula within engineering and science eg. Medialogy. Such programs appeals to students graduating from technical colleges. They are primarily trained in practical task oriented skills and focused on product development. These students, however, lack the PBL learning approach as introduced in the first year of the engineering education. This is mainly due to the fact that such students can obtain merit transfers for the first year in university, which means they are not educated in the basic principles of PBL and they do not have the possibility to work from the start in a PBL project.

A major problem appeared within the new Medialogy program at Aalborg University. This education, first established in 2002 (Nordahl et al. 2004) is by student size very popular. The education was originally

planned to provide further education to graduates from short 2-year programs such a Multimedia Design and Computer Technologies. The intention was to elevate the students to a bachelor or master degree.

Observing the behavior of such students we noticed that, although they were trained to PBL pedagogical methods used at Aalborg University when entering university in their second year, in their opinion such method was considered unnecessary. They could not use the PBL approach. Moreover it has been noticed among faculty that students had a difficulty to adapt to more common characteristics of university students. The department of Media and Technology was new so it could be defined as a developing community of practice which was not strong enough in its own apprehension and had not developed a common sense of identity (Wenger et al 2002). This state of the department with many new teachers combined with the specific group of students might be part of the problems because there was not a common understanding among the teacher about the PBL approach. (The same problems were noticed in another new engineering program, Architecture & Design).

In this paper we address the problem concerning the above mentioned groups of students starting their 6th semester without having the necessary PBL knowledge. As mentioned above, such students were exposed to an introductory course on PBL on their introductory semester (the 3rd semester), and they had carried out one project each of the following semesters. The student group is composed of 78 students all enrolled at the Medialogy program at Aalborg University in Copenhagen. While their 5th semester projects showed rather strong task solving qualifications, more than two third of the student mass did not use methods connected to PBL, such as structuring the project according to acknowledged PBL means. Such tools within this framework include proper problem analysis, problem formulation, scientific and theoretical reflections etc. (Cowan 2004). Our assumption was that the students would highly benefit from realizing the importance of structuring projects according to PBL methods, still using their previous experience. The solution was to organize a 3-day workshop – a learning lab where students would learn the PBL methods emphasizing the theme of the semester, while motivating and activating their desire to learn. One of the goals was to provide to the students the means to analyze their own previous projects, with a special focus on improvements in problem analysis and problem formulation. For their current 6th semester, which they were entering, the main goal was to formulate a valid problem seen from a problem based approach.

This paper describes a workshop with the aim to teach a special group of students in a bachelor program to use the Problem Based Learning (PBL) approach to define problems, structure and framework.

It is important to notice that the issues introduced in this paper also apply to master programs, where students might have graduated with a bachelor degree from universities not using PBL, and therefore need a special introductory course setup.

The workshop dealt with is a case study and the methods are action research where the organizers of the workshop participated as well as planned the activities. The content and the outcome of the workshop are analyzed through observations as well as interviewing students and teachers. The workshop is based on the learning theory described as The Aalborg Models theoretical approach. (See Kolmos et al 2004)

The theoretical PBL approach at Aalborg University

In new programs such as Medialogy which combine technical and humanistic subjects it is very important to give the students sufficient tools to structure their learning process. We have decided that emphasis on PBL and strong awareness on methods and theory of science could give the students the needed support. The students are told that we want them to be problem solvers when graduate from university. To achieve this goal learning and teaching need to have a special focus, different from other technical or humanistic. Students have to be competent in both areas educations. In the Aalborg model time is equally divided in project work and courses. Some of the courses (SE courses) have their own examination, while other

courses support projects of the students (PE courses). Such project-courses are evaluated through the project exam. The courses need to focus on the interdisciplinary possibilities, even the math courses, and it is in the project that students can integrate the technical and humanistic knowledge

To help students and supervisors not familiar with the PBL learning, it can be quite overwhelming to understand the underlying theories. To make such introduction more accessible we introduce a special version of Kolb's learning circle. (Kolb 1984). Kolb's learning circle in this form describes how people learn from either experience or from abstract theories. Kolb calls this the comprehension dimension of learning. The knowledge can then be transformed through a reflective process or through carrying out experiments. This is the transformation dimension of learning. Through this understanding the students are much more aware of the need for reflections as well as the learning experienced as a process well connected to the work with their projects.

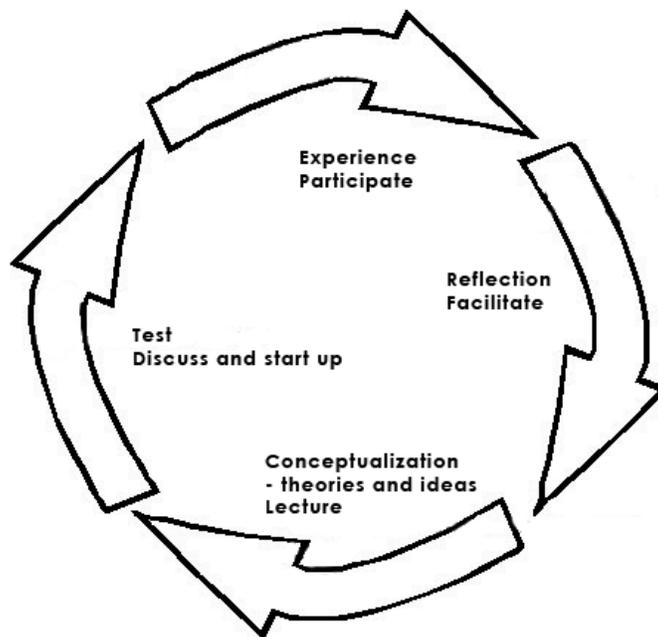


Figure1. Kolb's learning circle. (Kolb 1984) The authors paraphrase the words in italics.

Each group has one or two supervisors and the supervisors can participate in discussions about previous experience, facilitate reflections, lecture on new theories and ideas or discuss experiments for students to try out.

When having courses the dimension 'test' is not used to the full extent. Many courses are having exercises and they could of course be a kind of test. But it is during the work with the project that the testing really takes place and leads to new experience, new reflections, new conceptualizations etc. That is why teachers and supervisors also have to take Kolb's model into considerations when using PBL so they know the possibilities in the different phases in the learning process.

The new program Medialogy

Medialogy is a program started at Aalborg University in August 2002. The goal of the education is “to develop problem solvers in a digital media age independent of tasks” (Nordahl, 2007). This goal is achieved by merging creativity, arts and technology through the development and cross-combination of areas and topics within the field of engineering technologies, computer science, psychology, sociology and arts. Such areas have until recently been kept apart by conventional standards. The program is concerned with the current and future needs of society, culture, industry, hardware and software. The purpose of the course is to provide students with a solid foundation in areas within New Media comprising both technical and creative aspects. Students graduating in Medialogy will be able to integrate and combine different fields of new media technology. In Medialogy, students typically are faced with questions such as: to which extent can computer games be made more interactive or to which extent can the borders between man and machines can be overcome?

The workshop in the learning lab

The workshop had a main goal. The students should be able to use the concept of PBL, and within Bloom’s Taxonomi (Bloom 1956) they should reach as a minimum the application level concerning their problem formulation, but we hoped that many would manage to reach the highest levels. The Taxonomy has 6 levels (knowledge, comprehension, application, analysis, synthesis, evaluation) within the cognitive domain from the simple recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which is classified as evaluation. The students do already use Bloom’s Taxonomy connected to their project work. They have to set their desired level of learning goals within their chosen subjects used in their projects using Blooms Taxonomy.

A sub goal was that the teachers connected to the semester should get a common understanding of the PBL approach and reach the same knowledge level as the students. The problem for the teachers was that they were new, and some of them came from foreign countries. The new teachers had got a brief introduction to the Aalborg Pedagogical Model and were all involved in a pedagogical course for teachers (PUC 2006), but needed practical experience with PBL as well as a uniform identity connected to the new education and department.

The duration of the workshop was 3 full days. The participants were all connected to the same semester; 78 students divided in 11 groups (with a mixture of different nationalities) and 8 teachers with very different educational background where 4 were experienced in using the Aalborg model. Only a couple of the teachers had worked together before. All teachers had to be present during the whole workshop, and each teacher got assignments as doing lectures and acting as supervisors for the students and for each other.

The workshop was scheduled at the very beginning of the semester and at the end of the final day the goal was that all groups should have a well argued problem formulation connected to the semester theme (each semester has a theme; for the 6th semester it is “Interactive Systems and Computer Games”).

The expectations to this workshop were not very high neither among the student nor the teachers. Therefore it was a rather large challenge to motivate and make clear that everybody could benefit from learning and using the PBL approach.

The teachers were assigned with various topics connected to their teaching area which they should connect to PBL in a lecture and at the same time they were encouraged to make it especially motivating towards the students. This was a new challenge for some of the teachers; while preparing their lectures in a PBL approach they at the same time had to learn this approach. When choosing this approach we actually were

building on the theory on ‘learning by teaching’ (Ruep 1999 and Rachimova 2007). It was not considered an easy task for the teachers.

Content of the workshop

The students were informed that the success criterion of the workshop was that they, without knowing the content of the courses given at the semester, could conclude the workshop with a very well-defined and feasible initiating problem formulation at least at the application level according to Bloom’s Taxonomy. Moreover, the students were presented with the idea that they should organize themselves in groups, not according to their personal preferences (a behaviour often observed at many educations at AAU and other universities and learning institutions), but according to the problem chosen. This approach is similar to what happens in industry where people are placed in teams according to specific problems to solve.

Day 1 - lectures and discussions:

- Introduction to the semester, people and theme
 - Problem vs Product based learning
 - Task solvers vs. problem solvers
 - Projects defined by solutions – Model for categorizing different projects and how problem formulation will affect process and solution.
1. Introduction to the semester. In order for the students to be placed in the same mindset, we initiated the discussion about the introduction of the semester from several relevant quotes. These varied from: “I am always doing things I can’t do; that’s how I get to do them” (Pablo Picasso) to “When you understand the middle, it is so much easier to find the beginning and end” (adapted by the authors). From these quotes a motivation was given for courses of the semester and lectures of the day. Perhaps even more important was the fact that such quotes acted as a motivation to remember that problem solving is all about analyzing the problem, knowing the appropriate tool and design the solution around it.
 2. Different examples of interactive systems were introduced in very illustrative ways, presenting problem based research, development and innovation within the fields of: logic and art, logic and games and logic and interactivity. Afterwards teachers of the semester lectured within the area of interactive systems and computer games, for example introducing different possible problems that the students will be confronted with during the semester. This lecture was an eye-opener for the students – but also for teachers.
 3. Then the Problem Based Learning model was on the agenda. After having circled around the PBL in the previous sessions it was now time to get into the basic understanding of PBL. To a great extend this lecture was actually a repetition of major areas, which the students had been introduced of when they started at Aalborg University 3 semester before. However, they could now relate their previous experience to the ideas of PBL. The students were now able to see the benefits of this approach. Perhaps this result was strengthened by the fact that the teachers had a more uniform perspective on why PBL is fundamentally a good working approach.
 4. The goal of the fifth lecture was to show how end results of any project are very closely dependent on how the initial problem is formulated. Through this the students were showed one method of sorting problems according to some criteria, with the motivation of discussing specific problem statements later on and pinpointing “problematic” problems. By doing this examples of problems were grouped by the nature of their solution types; each having their own strengths and weaknesses as well as an appeal to different scientific disciplines. Through this the students were displayed the ability of PBL to structure their project work and focus their attention. Different examples of good and bad formulated problems were introduced. This would later on in the workshop be used actively by students as well as teachers as both a starting point for discussion of

problems as well sorting and deleting “irrelevant or bad” problems. The main conclusion was the importance of finding well motivated problems, placed in a context, not too open ended, not too specific so there would be no general appeal, but at the same time it should be testable and likely to be the focus of other people’s interests.

Day 2 - lectures and discussions:

- Scientific Methodology according to different disciplines which will be represented throughout the semester
 - Study discipline
 - Start of brain-storm for initiating ideas – a collective event, where all teachers, supervisors and students participate
 - Between day 2 and day 3 the students are sent home to analyse and reflect about the initiating problems that have been formulated.
1. The second day started with the question; what are scientific methods? The reason for this part was that being aware of the chosen methods is essential for working with a problem based approach. The main questions of this lecture to the students were: What are you doing, how did you do it, what kind of choice did you made – and why, what kind of methods do you want to use and why, what kind of methodology did you use and why, how could you improve the methods in your project, how is the correspondence (the red line) in your project with your problem – methods – theory – analysis and conclusion? The lecture ended with how the above raised question could be done in a PBL project.
 2. After this lecture the students were randomly put into groups of 5 people and given project reports from the previous semester. They were asked to analyze the problem formulations with the newly acquired skills and tools from the lecture on methodology as well as the experience from the previous day. To facilitate the discussions, the teachers were also part of the evaluation of the reports and took great part in the discussion. While the teachers believed to be in the position of supervisors, from the point of view of the authors, they were also unconsciously trained in reflecting over the approach towards formulating problems with a PBL point of view. This was an important observation for the authors, since as stated previously a sub goal of the workshop was the simultaneous training of teachers and students. At this point of the workshop, the students already started to show an increased maturity and acceptance of lack of academic competences regarding PBL approaches to their work. To conclude this part of the exercise, each group had to present the faults they believed were present in the reports that they had been given to analyze. At the same time, they were also asked to reformulate the problem of such report in an improved manner.
 3. The topic of the second lecture of the day concerned study discipline. Such lecture was introduced due to the visible lack of discipline among several persons in the group of students. Such behavior obviously frustrated the more disciplined in the student group as well as the teaching faculty. Notice that this subject is also a subject which is normally taught and trained during the ordinary first year, which this group of students have not experienced for reasons described above. The lecturer was a young PhD student, with a more classical education from Aalborg University. We believe that because of his casual appearance and younger age, the students could easily identify with this teacher and therefore understand his points.
 4. The last activities of this day, was a free brainstorm among students and teachers for initial problems. 42 problems were formulated and none were discarded at this point, even though some of them later on may seem similar. This session ran for a predefined amount of time. After this the students were told to group the problems according to the categorization of which solutions they believed these problems would belong – connecting this strongly to the method and lecture given the first day of the workshop.

- At the end of this day the students were send home to reflect over this categorization, how to limit the list of problems by sorting out the most relevant ones and erasing the irrelevant or redundant problem themes.

Day 3 - activities and implementation:

While the two previous days were run as lectures and discussions with the students, where the teachers were very active, Day 3 was signified by the students becoming active while the teachers were facilitating and observers of the process.

- Limitation and constraints of problems
- Implementation of the model of categorization for project types
- Ending notes from coordinator
- Task and immediate deadlines – students were given the dates for the first milestones (example: 20 page well-defined and argued project proposal with proper literature search must be handed in after 3 working weeks)
- Group forming – no student can leave the room until all students are in groups and every group have chosen a final problem from which they cannot deviate during the semester (but of course are allowed to refine).

The concluding day of the workshop was dedicated to further analysis of the problems formulated the previous day without further lectures. Here the students were actively working in continuing the process initiated the previous day. Such process consisted of an active discussion among students, but facilitated by teachers, on the limitations and constraint of the problems. During this process the students were asked to further “trim” the problems until achieving a small set of valid problems that would eventually, if solved, represent different solution types. From the initial 42 problems a set of 18 problems were selected and classified within 4 categories.

As last part of the day the student were informed of immediate deadlines and that they now had to organize themselves in groups, not choosing from personal preferences such as friendships, but instead focusing on choosing which problem were interested to solve. At this point, the teachers left the room waiting for the students to organize themselves following one rule above all: no groups were finalized until all students had placed themselves in a group. This process was further encouraged by the fact that the students were told that when they had selected a problem, they would not be allowed to deviate from it during the semester.

The student’s evaluation of the workshop using the Delphi Method

Using the Delphi Method (Gomon 1991) to evaluate the workshop the students were asked to indicate what was good and what could be improved. The following shows the students 5 top scores:

What was good	What can be improved
The best PBL course ever – because this time it was an informal discussion rather than a lecture (67 students)	The workshop should be at the third semester (70 students)
A new and better way to start a semester (66 students)	We should do this each semester (58 students)
Clarification of methods and procedures according to the PBL approach (58 students)	Integrate PBL in supervision (42 students)
Reflecting our previous work (49 students)	The supervisors should integrate PBL in each semester (40 students)
Get to know teachers (45 students)	We knew the stuff and found it was waste of time (28 students)
Seeing most of the students attending (41 students)	Too much debate (28 students)

As can be seen many of the students seems very satisfied with the workshop, and it is interesting that one of the scores tells that it was good to get the possibility to know their team of teachers, but also that seeing that most of the students were attending was remarked. The students are right when they say that PBL should be integrated in supervision, this is something to improve among the teachers. They are also right when saying that the workshop should have been at their third semester. This is a lesson learned after this workshop; it has to be at the third semester as well as at the seventh semester. It is fine that at least some students find that they know the content of the workshop, but it is something we have to consider next workshop, how to coop with the students who know about the PBL approach.

The goals for the workshop were fulfilled. The immediate result was that the experienced students in a very convincing way could build upon their previous experience and from there using the PBL methods to start their problem analysis. In the long term the students show excellent work concerning problem formulation, structuring their learning and their conscious use of methods.

The students have all reached a higher level according to Bloom's Taxonomy than being able to use the concept of PBL. Many students are able to discuss and analyze and even being critical. Half of the problem analyses were at the level between evaluation and synthesis, and the other half was on the analysis level. But a new problem has risen; the students want to make their problem analysis and problem formulation too perfect, so they are spending too much time working with those aspects.

Teacher's reflection of the workshop

The results showed that the workshop was successful. Form the teacher's viewpoint, during the tree days innovative problems were constructed and a significant transformation of student behaviour was observed. Furthermore, the workshop also showed while there is a demand for multi-disciplinarity and this is reflected in the staff coming from many different academic disciplines - and often behaviour of misunderstanding and miscommunication can be observed, but when approached in alternate ways it can produce fruitful collaboration and improved understanding of colleagues coming from other fields.

Quote from one teacher's reflection document at day 2: *"The teacher team is clearly working together after day 2. We seem to know where everybody is coming from and accept that fact. More importantly, I think we will be able to make a more uniform (team-like) appearance to the students, since we now have some degree of consensus about PBL."* This quote, we view as unique in the sense, that it achieves to express the overall reflections from the teachers involved and what they wrote in their reflection documentation.

Conclusion and perspectives

As can be seen most of the students seems very satisfied with the workshop, and it is interesting that one of the scores tells that it was good to get the possibility to know their team of teachers, but also that seeing most of the fellow students was remarked. The students are right when they say that PBL should be integrated in supervision, this is something to improve among the teachers. They are also right when saying that the workshop should have been at their third semester. This is a lesson learned after this workshop; it has to be at the third semester as well as at the seventh semester which are the semesters where students without PBL experience can start. It is fine that at least some students find that they know the content of the workshop, but it is something we have to consider next workshop, how to coop with the students who know about the PBL approach.

It was not easy for experienced learners to acknowledge that they need basic knowledge about PBL. But as the workshop was named a Learning Lab and was based on the idea that the students should use their experience and with this find out what they needed the reflections helped to analyze that the deep understanding of the methods of PBL could help them to design better projects they accepted that the new knowledge was needed and very valuable.

It was also important that students experienced that they could still use their previous knowledge and experience. In interviews they appreciated that they now understood how they could build upon their gained experience whatever it was good or bad and use it in their new project. Furthermore they stated that the compressed workshop and the fact that all teachers were present were good because it gave them the real feeling of creating and sharing knowledge.

The teachers evaluated the workshop continuously. They also expressed great satisfaction with the results for the students. But also the teachers had learned quite a lot about PBL. The lectures they were ordered to give had been very hard to accomplish, but thinking PBL into their subject areas had given them a new insight in the possibilities of integrate PBL methods in their pedagogical efforts. So learning by teaching had been very fruitful. Furthermore they had never known so much about each others subjects which gave inspiration to new way of teaching and design of new courses.

The teachers now have a common understanding of PBL, and have suggested that they should refine their skills within the learning theory. All teachers from the department are now offered a brush-up course in PBL. A learning lab is to be an important part of the department Media and Technology.

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