Experiences from Direct Application of the PBL Method in Industrial Training and Organization Development

Bengt Lennartsson
Department of Computer and Information Science
Linköping
S-581 83 LINKÖPING, Sweden
BLn@IDA.LiU.se
http://www.ida.liu.se/~bln/

POA, Kristina Davidson
Box 631
S-581 07 LINKÖPING, Sweden
Kristina.Davidson@POA.se

Abstract: *This paper presents some of the finding in a case study followed by an action research effort, where the PBL model has been used in the development of an industrial training program for electronics design engineers. There are some major differences between the development of ordinary university curricula on one hand, and the training of design engineers in industry on the other.*
The tutorial group model with its nine step cycle has been directly inherited from the ongoing undergraduate PBL programs within Linköpings Universitet.
However, also components used in the project-organized education, used in engineering programs in for instance Aalborg and Luleå since the seventies, have been exploited. The cases used in the industrial tutorial groups have been taken from the actual work environment of the participants; the last case was unified with the long term task of the group.
The tutorial group has been viewed as a team to be trained, and not only for the support of the individual learning. One special aspect has been the multinational composition of the group; the different members quite clearly have made different interpretations of concepts as team work, project group, and group leader.
The activity during the spring 1996 has been aiming at the definition of goal and target group for the development of the training program. In the next step, the execution of the training program developed for a larger group of engineers, video conference technique will be used for tutorial group meetings distributed over Europe and North America.
This paper focuses on the development of the program and in particular the participatory and the process oriented aspects of the development.

1. General Context and Research Method

In general the very fast technological development makes it necessary to develop an ability to learn how to learn among the design engineer and the design teams in industry, rather than to rely upon courses and seminars offered by some central department for education and training. At Linköpings Universitet an undergraduate program in Information Technology started in 1995, and this program is from its beginning based on PBL, and our assumption was that this method can be used also in an industrial environment.

The observations reported in this paper are from an organization development project within an international organization. The PBL method was used in industrial training and organization development. The paper presents the experiences from the development of a training program, with the focus on the participatory and process oriented aspects of the development. The author Lennartsson was during 1995 involved as a reviewer and observer in the definition of a global strategy for the introduction of new technology into the products and into the development process of the organization.

In a second step, both the authors were during the spring 1996 engaged in the development of a training program for a group of about 60 electronics design and development engineers. The program developed was intended to be used globally, but initially it should be executed in Europe with participants from Sweden, Germany, and Italy. The objective has a purely engineering component: to introduce new technology, new design and development tools, etc., to the participants. However, there is also an other component: to change the behavior and the attitudes towards a more flexible, independent, and pro-active behavior.

The research method applied has been the case study, concerning the identification and definition of the problem to be solved: How should the organization and the attitudes be changed to become in harmony with the new goals in the organization?

However, once the objective for the education and training had been defined, the authors have participated not only as observers and reviewers but also as active supporters of a particular training method, problem based learning organized in tutorial groups. So the methods used are partly observing and reporting a case study, and partly action research in the implementation phase.

2. The Background

The global strategy within the organization defined during 1995 required new attitudes and a new kind of behavior of the design and development engineers. It was early identified that as a first step towards the new strategy, a new education and training program had to be developed during the spring 1996. This program should then be executed from the fall 1996 on. The PBL method was a strong candidate for the execution, and in order to gather some experience from the method within the organization, it was decided that PBL and a tutorial group should be used also for the definition and development phase during the spring 1996. This paper reports the work done during this period together with the results and our major conclusions.

2.1 PBL at the Faculty of Health Sciences, Linköpings Universitet

PBL has been used as the general model for all the undergraduate programs within the Faculty of Health Sciences, FHS, at Linköpings Universitet, since 1986. There is a large amount of experiences from curriculum development, from the processes in the tutorial groups, definition of cases, etc., to build upon. The PBL Method, as executed in Linköping, is characterized by three factors:

- Realistic cases are starting points for the learning process
- The path from the starting point to the goal is determined by the students
- The cases are penetrated in the tutorial group, where the learning needs are defined and checked

The author Davidson has been involved in the development of a Masters Programme based on the PBL method in Public Health at the Faculty of Health Sciences, Linköpings Universitet.

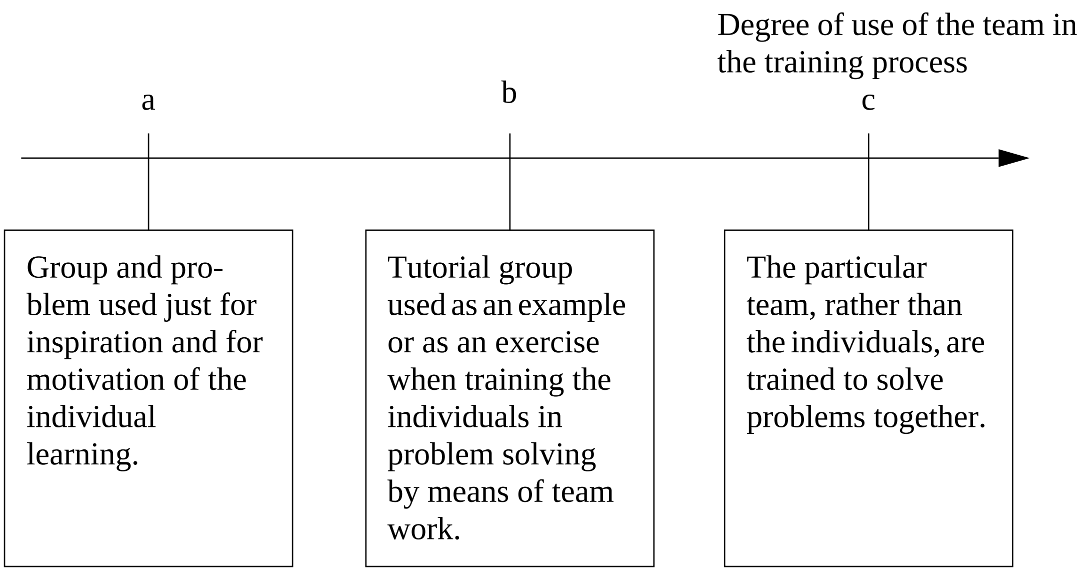
The PBL model used within the Faculty of Health Sciences has almost as it is in 1995 been inherited by the new Information Technology Program within the School of Engineering at Linköpings Universitet. This four and a half year program is now in its second year.

2.2 Project Organization in Engineering Programs

The relations between 'Problem Based Learnin'g and 'Project Organized Curricula' has been discussed and analyzed before; see for instance Günter Heitman: *Project study and project organized curricula: a historical review of its intentions*, and Erik de Graaff: *Problem-Based Learning in Engineering Education*, both in [2]. In the seventies there were many experimental engineering programs set up based upon 'project organized', 'problem oriented', or 'student directed' models. In particular *The Aalborg Experiment* [3] is well known. At the same time the author Lennartsson was responsible for the development of the *Industrial Electronics program at LuleŒ University* in Sweden. That program was based on ideas similar to those in Aalborg, and it is still in operation [4]. One of the major differences between the model used at FHS and the model used in Aalborg and Luleå, is that at FHS the tutorial group is just an instrument for the learning/teaching. The responsibility for the organization of the program is in the hands of the teachers: The composition of the tutorial group, the decisions about time and content for supporting lectures and similar activities are handled by the teaching staff. Most of the meetings in the tutorial groups are scheduled by the teachers.

In engineering programs the organization is often considered to be part of the content in which the students should be trained. An engineer has to be able to work in project groups, to take the full responsibility for the organization of such work, to be able to handle situations where tensions and other disturbances occur within the project group. Hence, in engineering programs it has often been natural to look upon the tutorial group not just as a mere instrument to motivate and support the student in learning and understanding the content of literature available in the libraries, but also as a group where the knowledge is initially created. This applies not only to the psychology and to the group dynamics aspects. An engineer should be trained to *create* systems, equipment, etc. that did not exist before. In almost all non-trivial cases the knowledge and understanding needed to grasp the problem, to understand how the problem should be solved, how the system should be structured, etc. evolves in the design group, and this understanding is something that exists in the heads of the design team jointly. Questions arising can be answered by the process taking place within the design team *in pleno*. The ability and the skills developed should not be regarded as individual attributes, it is rather a relation belonging to the team as a whole.

Of course, this training of the creativity.and team understanding capability is more obvious at the end of an engineering program than at the beginning. Also students in engineering have to start with getting the existing well structured basic knowledge available in text-books and other publications in the library and in the bookstore. However, on top of the existing basic and applied subjects, there must be some training in how to use all this to be able to attack yet unsolved problems, to learn how to design and develop apparatus and systems that do not exist.



In normal undergraduate engineering programs, however, the objective is to train the students as individuals, to have them prepared for later contributions to different development and design teams. In industrial training programs it is often possible to train the *real design team* as it is.

In the figure above, case **a** represents the FHS model, and also at least the first two years of the IT program, whereas the cases **b** and **c** represent the model presented in this paper. We would like to place the model used in Aalborg and in Luleå at level **b**. Level **c** is appropriate for continuing education of design engineers in industry.

We are not ure teachers from FHS in general would accept the description above, that creativity should be required by engineers and not by nurses and physicians. However, it is quite clear that the models chosen and the use of the tutorial group are very different in engineering and in medicine.

To summarize: for the tutorial team in engineering education and training all the aspects available in health care programs are present, but often also other components are considered like team learning and the creation of knowledge and understanding at the team and not only at the individual level. Hence, in engineering it is normally accepted, and even encouraged, that the students develop *different* individual skills and understanding profiles. The goal for required performance and ability may be at the team level. The team is expected to develop ability to create systems that did not exist before and to solve problems where solutions are not available in the literature.

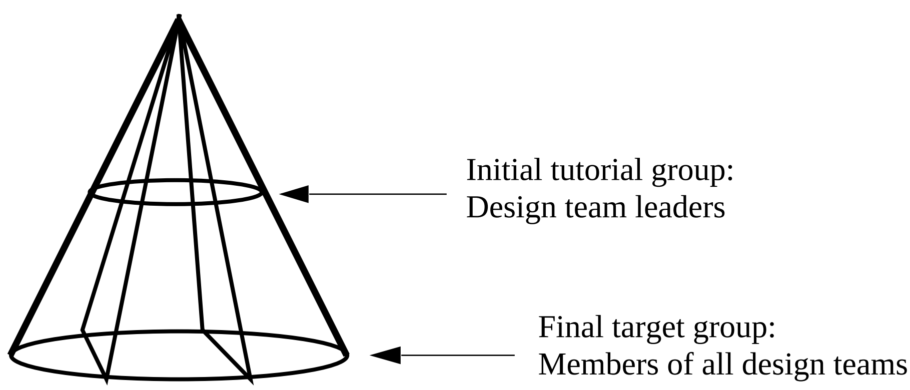
3. The Goal: Enable a Pro-active Behavior

In the industrial training program developed by the authors during the spring 1996, the idea of a pro-active behavior [5] was one of the corner stones. In the development process used to date, it has been assumed that there are requirements and specifications coming from somewhere to the design and development engineers. It was very important to prepare for new technology and for the use of new simulation and animation tools in the design process. However, the most important requirement was to change the general attitudes and behavior patterns. Instead of waiting for instructions, the design teams, and the individual design engineers, should be pro-active and know in advance what to do. They should aim at having the answers available when and if some new questions came from outside. The most important goal was to reduce development time, and the means to do so is to shortcut the writing and reading of detailed specifications not followed at the end anyhow. There are also cost and quality goals, but they are also supported by the pro-active approach.

The strategy is to take the technical lead, not to develop ability just to copy products and ideas released by competitors.

4. Layout and Implementation

There were three tutorial group meetings during the spring 1996, each of them for two days. The time between the meetings was about one month, and the participants were expected to contribute to the task of the group by doing some individual home work. The leaders of the design team were trained both in the content of the new technology and in the training method; Problem-Based Learning.



The idea was that the members of the tutorial group should be able to take the responsibility for the future training of their own design teams. However, the organization should have support and resourse persons available when needed.

5. Results and Conclusions

A general conclusion is that the PBL model was very useful in the development of the industrial training program. The discussions and the analysis within the tutorial group enabled the change in attitudes towards a more pro-active mind.

A second conclusion is that the new requirements on the skills of the design engineers should also be considered in our ordinary undergraduate programs.

- ABILITY TO LEARN more important than static knowledge
- ABILITY TO COMMUNICATE AND TO COOPERATE more important than individual brilliance
- ABILITY TO UNDERSTAND TOTALITY more important than narrow deep knowledge
- ABILITY TO ACT AND ASK QUESTIONS more important than ability to follow detailed instructions.

A third conclusion, mainly related to engineering, is that team understanding capabilities probably the most important success factor in industrial development projects. Such observation have been made in engineering in general [6], and in software projects in particular [7].

The possibility to develop different individual skills and profiles is something regarded as a feature in both ordinary engineering curricula and in industrial training. A difference, however, is that in industrial training programs it is very useful to allow a case to be the reality, or a special aspect of the real situation.

As a next step in the research project we will investigate the possibility to work with distributed tutorial groups having their meetings by means of video conferencing equipment. The group will meet physically the first time to establish the general confidence and the person-to-person relations, but later on about half the group will be in one room in the US, and half the group in a room in Europe, and the two semicircles will se the other half on a large video screen.

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