# Innovations Based on Interaction between Students, Industry and Academia: Case Studies from PBL and Learning Laboratories

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**Abstract:** Within two different departments in our university college, we have been practising a mixture of PBL and traditional lectures in the field of process measurements and multivariate analysis. A considerable part of the assessment weightage was given to the semester project, which is done by a group of students in close collaboration with the industry. Almost exclusively the problems were defined by the industry in close collaboration with the learning lab triangle consisting industry, academia and students.
In this paper, we present our experience with different semester projects and critically look at the process to discover possibilities of improvements.
Finally we look into the model of learning lab development in close collaboration with the industry. The experience with the learning laboratories is interesting to the members in the learning triangle considered by us. This approach opens up new possibilities for the students, academia as well as the industries.

**Keywords:** PBL, learning laboratories, industry, academia, students, SIA-triangle

## 1. Introduction

The interaction between the students, industry and the academia is a feature, which should ideally be promoted by all these three important participants in a modern society. Engineering education should be planned, held, developed and if necessary should be modified in conjunction with all these three participants, whom we call in the context of this paper as "SIA". The national or regional authorities should come out with guidelines and directives, which foster such an interaction. In practice, this is not easily achieved, although all parties support such collaboration with great eager.

The extent of such collaboration is very much dependent on the persons involved from each categories represented by the corners of the SIA triangle shown in Figure 1.

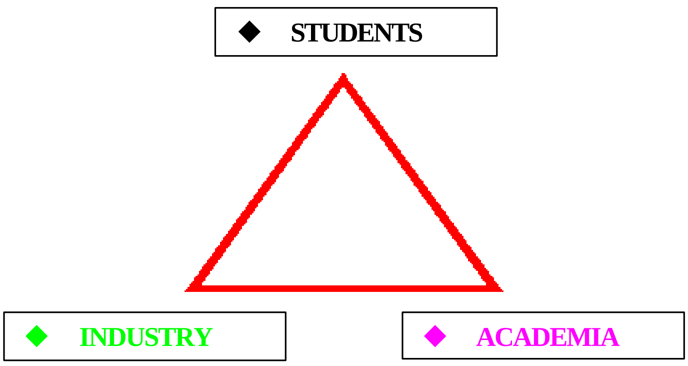



Fig. 1. The triangle of interaction, called SIA- triangle in this paper

The reluctant industrial partners, who are not always willing to accommodate students in project assignments or who do not have time to supervise students after agreeing to project assignments are very often made to remember by one of the authors of the paper that they were also students at one time or the other!
This paper portrays a positive collaboration in a SIA-triangle, functioning fairly well in the city of Porsgrunn, where Telemark University College is situated.

## 2. SIA –Triangle

### *2.1 Students*

The primary aim of any educational organisation is to foster the following concepts among students. These concepts are reproduced from [1] with some modifications.

Table 1. What the students should be able to do and what the teachers should promote in the process of teaching

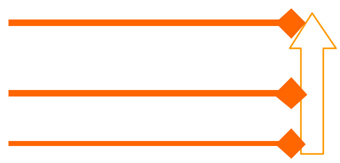
| **From Thalmud.** | **Johan Amos COMENIUS** |
|---|---|
| Teach your tongue to say, “I don’ t know”, when you are uncertain | From the known to the unknown |
| Always teach your pupils in the shortest manner | From the closest to the furthest |
| Teach from the known to the unknown | From the local to the national |
| Teach from the simple to the complex | From the concrete to the abstract |
| Make the subject of study clear by means of illuminating examples | From the easiest to the more difficult |
| | From the simple to the complex |
| | From what we can to what we cannot |

If students can manage to do a particular job in a group, the same students will be able to accomplish the same job in its possible variations in future, with or without the help of others.

### *2.2 Academia*

The teacher irrespective of the subject matter and capacity of students should be able to elevate the knowledge of the class of students as a whole, as depicted in Table 2. To achieve this type of improvement, the teacher should be competent in the subject matter and general pedagogy, versatile with context specific issues. The teacher’ s subject related didactical overview and ability should reinforce these.

Table 2. Knowledge levels achievable by students with and without collaboration

| **Achievement (Knowledge) Level** | **Level** |
|---|---|
| Level achievable when the student gets collaborative support (**LEVEL 3**) |  |
| Level achievable when the student works alone (**LEVEL 2**) | |
| Present Level (**LEVEL 1**) | |

### *2.3 Industries*

In our view the industries, as the future market for the engineering students are customers and should act like mentors to promote the process of enhancing the knowledge/achievement as shown in Table 2, which applies not only to the students but also to the teachers.

### *2.4 Interaction and synergy benefits*

Interesting aspect of a positive SIA working relationship is that the process has a tremendous synergy effect on all parties in the SIA triangle. We think that the SIA-triangle and the level enhancement are applicable to all parties involved. Many authors discuss previously the benefits of co-operative learning, as in [2,3]. It is our belief that these benefits are not only at individual student level but are shared by all parties of the SIA triangle.

## 3. Case studies taken up for PBL in autumn 1999

We give the list of case studies we took up in autumn 1999 in collaboration with different industries as part of a PBL in an MSc course on “Modern Sensors and Systems”. The problems were discussed with the teacher and the lab-engineer in the university and the technical experts in the various industries. All the students following the lectures were invited by some of the firms to visit the facilities and to discuss the issues with technical personnel at site before they decided to select the projects.

Table 3. Case studies taken up for the subject “Modern Sensors and Systems”

| Company | Project |
|---|---|
| Norsk Hydro | (1) Prevention of Pressure Escalation in Ammoniac Heaters |
| Norsk Hydro | (2) Production Optimisation |
| Norsk Hydro | (3) Level Measurement |
| Ulefos Jernverk | (4) Temperature Measurements in Molten Metal |
| Norsk Hydro | (5) Level Measurement in Ammoniac Tank |

We look into one of the projects in Table 3, viz. case (2): Production Optimisation. This project was a collaboration between the institutes of process automation and process technology of the Telemark University College and Norsk Hydro. The results from this PBL assignment have been found to be very promising and are presently considered for process improvement by Norsk Hydro. More information on such case studies and learning laboratories can be found in [4].

## 4. Learning by doing: views of a student participant (IHM)

Studying to get a degree has the goal of being best prepared to deliver good job performance in future working environments. The humane, social and ethical aspects will have to be covered and discussed elsewhere and we do not dwell on these issues in this paper.

There are many ways of learning and testing how well students have acquired knowledge of a particular subject. Each of us might have different way of learning and the teacher’ s challenge is to teach all of us in such a way that we learn the **important basics in a subject**. The small details can always be understood/updated and one can look up in appropriate documents if one knows the basics.

So, what is the best way to teach technological/scientific topics? This is a question asked by many teachers and students. There is certainly no unique method, which could be selected as the best way, but one has to vary the teaching method depending on the topic and the group of students one is working with.

One of the methods with the needed flexibility is " learning by doing".

From the time we were born, we "learned by doing". This is often the teaching method adopted in primary schools. Later on, when we start in college, we start to deal with abstract concepts. In this process, the teacher centred pedagogy evolves in many schools worldwide.

### *4.1 Technological development and curriculum content*

Independent of the method used, to be successful in teaching, the teacher has to be well prepared. The teacher must have clear ideas of the learning process and goals **before** taking up a new topic or giving projects. The teacher can motivate a student to learn and can prepare and try to create a good learning situation or environment. The student will thus be encouraged to experiment with new ideas and applications.
By clearly defining a goal of the teaching in the start, one helps the students to focus on what's important and to disregard things that are not important. Using this selection process, one helps the student tuned to the reception and utilisation of knowledge that is relevant and appropriate for the problem in hand.

In the technological sector, we have experienced and are experiencing a trend of exponential growth of know-how. The material coverage in a classroom situation will be impossible, if one has to take all the latest developments and at the same time cover the basics.

It is almost like a growing competition, in certain learning environments, on who can put the most into subjects in a particular year. Such teaching is doomed to be superficial and inefficient, so much so that students don't learn the basics well enough, and are forced to focus on exams, very often ignoring the acquisition and application of knowledge.

Is this good enough? We do not think so.

One of the co-authors of this paper (IHM) just attended a series of lectures on "Modern sensors and Systems", in which "learning by doing" was the main method. The views expressed in this section are mainly based on this learning experience.

*4.2 Advantages of PBL*

This exercise of learning by doing, gave the students many positive challenges because of the following points:
A: Learning to work in groups.
B: PBL
1: Students were given various tasks in collaboration with the industry, thus learning the communicating methods used in the industry.
2: Students had to learn about the industrial process and environment
3: Students had to follow industry procedures in handling chemicals, materials and equipment.
4: Students had to be **creative** and find solution to their problems and choose appropriate sensors, having the technical and economical aspects always in mind.
5: Some of the students decided to run some tests, just to verify that their solution worked
6: Write a report.
The most positive aspect with this "learning by doing" with this kind of project, is that students in a group had the induced possibility to be **creative**, which would have been almost impossible to achieve in this form in traditional teacher centred learning environment.

**Some of the students realised that they were very good in solving practical problems**, not just the theoretical ones. Many new ideas were taken up and this process alone helped to boost the motivation - which is very essential for active learning.

Many students have the experience from most traditional classes that the channels for promoting creativity in solving problems are limited to which "trick" they should use to solve the problems to obtain a definite answer. The project based activity in conjunction with the industry opens up new channels, where the solutions might not be unique. The different solutions evolving out of the PBL reinforce the learning process and lead to an active learning environment.
The students also learn how to communicate with the workers in the specific industry plant. The communication forms differed from place to place.

Usually, the results from such projects were positive and very often were evaluated for use in the industry.

*4.3 Motivation in PBL and final examination*

The set of goals of the project in the context of PBL was to learn about practical problems, sensors, security routines, and communication and to gain an overall understanding of the subject. By using practical work one could achieve this set of goals more efficiently than in traditional teaching and learning classrooms. The model, we have used here can also enhance the learning of theory via practical work in the industry.

The examination form has also a n impact on the motivation for the different ways of learning. If the examination has a dominant focus on theoretical knowledge, the students won't be motivated to do laboratory and practical work with the same eagerness.

The examination was based on the report and oral presentation of the project description and results from the activities of the members of the project group PBL.

Due to the fact that the Telemark University College has a formalised collaboration, the type of activity for the students described here could be described as learning laboratories, where the laboratories are spread in the environment and made available to the students.

## 5. What the learning laboratories can help to achieve

In the process of learning, the students should be able to recognise, reproduce, understand and apply the knowledge after having worked with a subject matter. The following figure depicts clearly the level enhancement discussed in § 2 of this paper.

The concept of learning laboratories introduced here for a want of better word, emphasises the need for student involvement right from the beginning and helps to build up the SIA-triangle relationship leading to improvements and innovations.

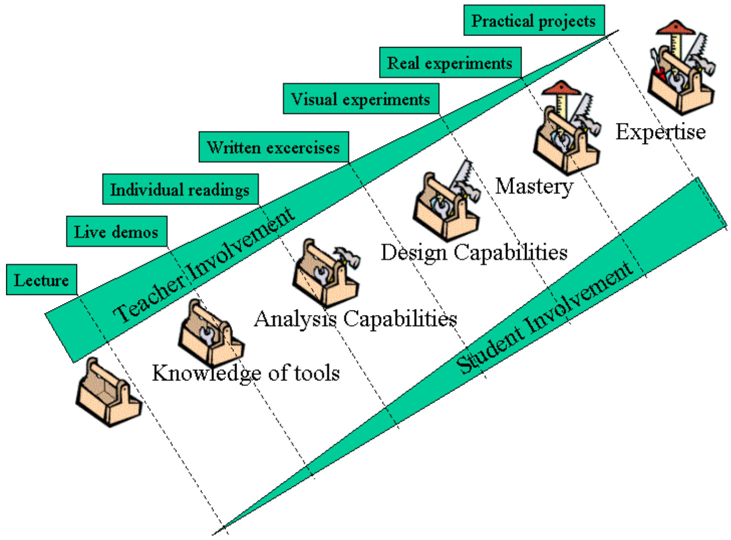



Figure 2. The teacher – student interaction in a project based learning environment. The students take more and more of the steering. The teacher becomes more and more of an adviser (consultant)

## 6. Conclusions

Many have tested the concept of using PBL in engineering curricula in collaboration with the industries. Our model is based on the increased student involvement in the selection of topics, right from the beginning using the SIA triangle and the learning laboratories. The learning laboratories are facilities made available by the industry for the evolving course content in an engineering curriculum in close collaboration with the academia and the students. The learning laboratories are dynamic and exclude the recycling of course material and content very much prevalent in many academic institutions, either at secondary or university level.

The success of the PBL arrangement and the learning laboratories are very much dependent on the interest and energy flow in the SIA triangle. Formalised agreements at the top are not enough to obtain the most out of such SIA triangle. Experience shows that individuals with interest for synergy benefits in the SIA triangle can promote this endeavour, thus leading to better curriculum content and better engineers for society in future.

## 7. References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[4] http://www-pors.hit.no/~sabam/index1.htm


## 8. Miscellaneous


Students of Telemark University College and engineers of Norsk Hydro have been very helpful in experimenting with the learning laboratories concept and the PBL used in the course of the autumn 1999 lecture series "Modern Sensors and Systems" held by Saba Mylvaganam. Thanks to Dr. Haima Mylvaganam for the valuable comments during the preparation of this paper.