Experience with Case-projects in Bachelor and Master Studies in Electrical, IT and Systems & Control Engineering

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***Abstract*— Inclusion of mini projects within a course is usually practiced at all levels in most of the universities/ university colleges with different names (such as course works, term assignments, projects etc.), and weights with respect to the course credits. In the context of this paper, these assignments are called case projects, as they are often case studies conducted as projects. Usually such an assignment will be given to a group of 3 to 4 students during the term with working form based on some aspects of PPBL (Problem/Project Based Learning). Three different cases are presented in this paper from three different intuitions in Germany and Norway. A summary of student and teacher experience from these institutions is also presented. The model of case projects included in a normal course (5 to 10 ECTS) in Electrical, IT and Systems & Control Engineering is compared with a full-fledged group project (20 ECTS) run in Telemark University College, which is tuned to generate new entrepreneurial ideas, which were presented in European arenas in the context of Student Enterprise and Young Entrepreneurs. A new PBL/PBBL methodology called Agile methods and Scrum is also presented. Agile methods and Scrum are predominantly PBL/PBBL methods are becoming popular due to their enhanced learning outcomes and are capable of being integrated into both hardware and software assignments. Brief technical descriptions of three different projects are also discussed. Case projects can be used as catalysers for injecting new ideas, form and content to courses in general, as found in the studies of such practices in the two nation involving three institutions.**

***Keywords* - PBBL, Case projects, innovations, Agile/Scrum, entrepreneurship**

I. Introduction

This paper presents some pertinent issues related to the inclusion of PBL/PBBL in engineering curricula as practised in one German (JUCAS) and two Norwegian higher educational institutions (BUC). This is not a study on pedantic usage of PBL/PBBL, which can be seen in institutions running courses purely based on PBL/PBBL. We look into the various stages and relevant aspects of PBL/PBBL and how these can be exploited for setting realistic and relevant learning goals and achieving appropriate learning outcomes in the collaborative efforts by the teachers and students practising a learning model using some elements of PBL/PBBL.

PBL/PBBL has been extensively used by the medical faculties around the world. Within Scandinavia, Roskilde University (RU) and Ålborg University in Denmark have a long tradition in the usage of PBL/PBBL. Ålberg University is seen as a trendsetter for PBBL. Similarly, TUC has strongly supported project work with interdisciplinary features since 1982. In TUC, the interdisciplinary nature has been stressed in the faculty of technology. In BUC, elements of PBL/PBBl are found in semester assignments in the Faculty of Engineering involving projects in engineering designs and IT projects.

II. PBL/PBBL – Pros and Contras

Traditional learning environments and students/staff involved in such environments were obsessed with problems and their solutions where the answers were unique and mostly given. In PBL/PBBL, the solution (answer) may not be unique and certainly not available at the beginning.

A combination of teacher-student classes, projects and practical problems is found to be attractive to the students and can help to define appropriate learning goals and set “measurable” learning outcomes, involving all aspects of engineering related to a given case study, encompassing hardware/software, design, testing and implementing the solution in a real life scenario, either in the industry or in the lab. This would stimulate students and make them interested in the topics and their sphere of influence/applications. This approach creates a platform for students’ independent thinking and innovativeness and leaves imprints on the students by engaging many facets of the topics covered during the studies by the students and the staff involved in the process.

Table 1

Pros and Contras of PBL/PBBL

Pros	Contras
Students learn to plan their own work and to do research and organise themselves. The teacher stands outside and is ready to guide and help.	Suddenly getting a project work can be quite overwhelming for students who haven’t been exposed to it. The teacher should take special care that the student

	comes through the planning and organising phase with satisfaction.
Students get a good preparation for later life, they will not always have their teacher to “feed” them with information	Special care should be taken of students who are doing this first time and are used to being fed by the teacher
Students learn to be more independent	May cause some 2spells” insecure moments. Teacher and technical staff should be always available for support/advice
There is a great chance the student learns more in a project, where he/she has to do all the research. This knowledge is not easily forgotten, whereas some of the information one otherwise learns at school is easily forgotten.	There is also a chance the students don’t learn much at the project, either because they didn’t succeed doing the planning and organising phase, or because the responsibility lies on their own shoulders, without a teacher to control them.
Students develop more interest to the subject the minute they have to organise their work and research themselves.	In extreme cases, the teacher may deliver a cook book recipe like material to the students. This can lead to boredom and indifference among students.
Collaboration with others and with people with different technological background	Demanding at times for weaker students
Students learn techniques related to project work (such as planning, meetings, minutes of the meetings, setting milestones etc.)	Demanding tasks for the teacher particularly when weak students form the majority of the project group
Students learn how to interpret different kinds of information sources, and to filter out reliable information	Different information sources can easily confuse students and the result may be that the students really can’t get a grip on the subject.
Students learn to plan and to follow the plan/schedule and to deliver progress reports in project meetings or web-based reporting	Needs well organizes meeting schedules and web-platforms for information diffusion
Students get a chance to show their innovative talents	Necessary hardware/software support should be available without failure.

Inclusion of PBL/PBBL in the curricula and involvement of and good interaction with relevant partners/sections of the industries can be of good “value” for both the students and the staff of both industries and the academia. This interaction has been referred as the “SIA” triangle, Fig. 1. The advantages of such an interaction based PBL/PBBL is schematically illustrated in Fig. 2.

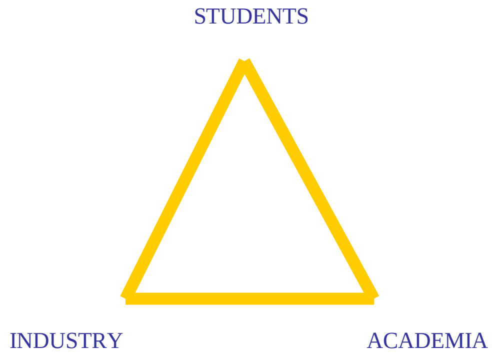

Fig. 1 The importance of SIA triangle in PBL/PBBL

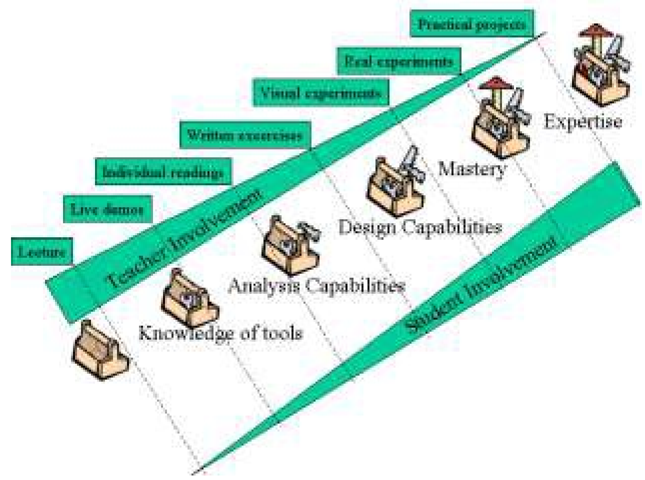

Fig. 2 The advantages of SIA triangle in PBL/PBBL showing the process from knowledge base to expertise. From [16]

III. Practice using term assignments in BUC

In BUC, some elements of PBL/PBBL are .found in the term assignments given to students in the Department of Computing, Mathematics and Physics of the Faculty of Engineering.

TABLE 2
ELEMENTS OF PBL/PBBL IN BUC IN SELECTED COURSES (NOT EXHAUSTIVE LIST)

Course Code	Courses & PBL/PBBL		
	Topic	**ECTS**	**PBL/PBBL or related weight**
TOD 061	IT Systems and Society	5	30%
TOD 076	System Development and Web Applications	10	30%
TOD 112	Developmental tools C#,/.NET	5	30%
TVE 077	PC Based Instrumentation	5	40% (T.A. and 60% oral exam mostly based on T.A.))

Similar approaches are used in many of the topics covered in the Faculty of Engineering at BUC. Most of the term assignments are based on the model based on SIA triangle.

Pertinent observations related to the term assignments and their assessments and impacts on students can be summarized as follows:

- The final grade is based on the grades obtained in the written exams and weighted incorporation of the grades obtained for the term assignments.. Term assignments are presented at the end of the term.
- Some students performing rather weak in the written exam get very much improved overall grades due to the grades in their respective term assignments
- Due to intensified focus on term assignments, some students may feel that their focus on other subjects offered during a particular term may be less intense
- Term assignments are very often interdisciplinary

IV. Practice using projects in JUAS

The examples presented here is from one of the Universities of Applied Sciences in North Rhine-Westphalia, which is the most populous state in Germany. University of Applied Sciences were founded in the 1960's. The Universities of Applied Sciences in Germany offer Management, Electrical Engineering, Mechanical Engineering, and IT and some of these offer also Civil Engineering, Architectural Engineering, Social and Health Sciences.

General strategy in JUAS as found in similar institutions in other neighbouring regions is to start with PBL/PBBL approach somewhat later in the studies, the reason being the need for the students to acquire the fundamental concepts in basic sciences and engineering concepts before they launch on projects. As a result, elements of PBL/PBBL are first found from the fourth term onwards, so that the students can use of broader knowledge base obtained during the earlier terms.

A. Project Engineering /Management

Students following Engineering Management has a spectrum of topics covering ~ 40% Engineering, ~40% Management and ~20% Integration of both disciplines. As the students need to be tuned to tackle problems involving engineering and management decisions, the projects defined do frequently have components from both disciplines.

In fact, the project is a component of the curriculum as shown in Fig. 3

B. Extension to International Projects

Starting some decades ago and now with increasing intensity, all the courses offered in the higher educational institutions strive to have international components/links. With this in mind, the courses in Engineering Management in Germany, belonging to the top export oriented countries, are designed to have international components in most of the courses offered.

Anlage 1.1: Modulkatalog Wirtschaftsingenieurwesen – 29.09.2009

Module, Prüfungsleistungen, Studienleistungen, Kreditpunkte und Gewichtungen für die Bachelor-Prüfung gemäß §§ 6,7 und 8 Teil A BPO

Pflichtmodule	**Semester**	**Arten von Prüfungen (§ 8 Teil A)**	**Kredit-punkte**
Mathematik 1	1	K2	7
Grundlagen der Ökonomie	1	K2	5
Externes Rechnungswesen	1	K2	4
Kommunikationskompetenzen 4)	1	KA oder K2	4
Grundlagen der Technik	1	K2	5
Technische Mechanik 1	1	K2	5
Mathematik 2	2	K2	5
Statistik	2	K2	5
Informatik 1	2	K2	5
Investition und Finanzierung	2	K2	5
Wissenschaftliches Arbeiten	2	KA oder K1	2
Zeit-/Konflikt-/Selbst-Management 4)	2	KA oder K1	3
Technische Mechanik 2	2	K2	5
Informatik 2	3	EO oder K2	5
Organisation und Führung	3	K2	5
Qualitätsmanagement	3	K2 und EA1)	5
Fertigung	3	K2	5
Thermo- und Fluiddynamik 1	3	K2 und EA1)	4
Elektrotechnik 1	3	K2 und EA1)	8
Organisation und Führung Seminar	4	KA	2
Kosten- und Leistungsrechnung	4	K2	5
Internationales Projekt	4	KA1)	2
Thermo- und Fluiddynamik 2	4	K2 und EA1)	6

Fig. 3 Project as an integral part of the curricula

In projects, it is mandatory that every group has an international partner. Very often, our partner organization in the Netherlands is involved in such PBL/PBBL based work. Sometimes, other international partners are also involved. The project is run by each partner institution sending and receiving 50% of the groups from each other. The language used in conjunction with the project is English. These projects are mandatory for all students in Engineering management and are supervised by two professors, one with engineering and the other with management background.

C. Some details on the international projects from the module description of JUAS

The PBL/PBBL component of the Project Engineering/Management should facilitate the students to tackle and solve complex problems from Engineering Management with interdisciplinary elements, involving real life industrial/engineering scenarios, with focus on technical, economical, ecological and social implications of the project. The project needs to be presented in a solution oriented form in a report and should be presented in a forum involving students, staff and industrial partners. The project group is self-managed and should disseminate information on the outcomes and methodologies of the project and help to train any future users of the outcomes of the project, The presentation in a forum should help the students to learn to tackle time and peer pressure and the process as a whole is planned to help the soft skills needed by an engineering manager.

TABLE 3
ELEMENTS OF OTHER DISCIPLINES IN PBL/PBBL AS USED IN JUAS

Technical Knowhow	25%
Economical Knowhow	25%
Management knowhow	25%
Analysis and Integration of the whole	25%

D. Some recent projects at JUAS

Some recent projects done by the students of JUAS and Netherlands are:

a. Planning a Windmill park – Technical and Economic Aspects
b. Planning a Heat Pump based power station- Technical and Economic Aspects
c. Different Real Life problems from Logistics

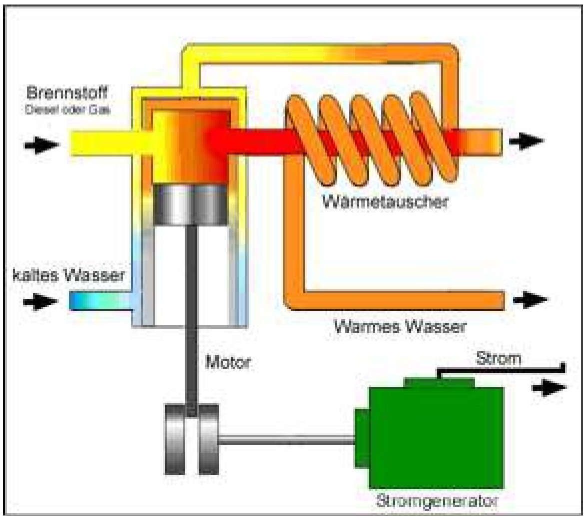

Fig. 4 Heat Pump based power station as a case study used by students of JUAS reflecting the current technological and socio-political trend in the energy market

Fig. 5. Wind Mill Park as being observed by German Chancellor Angela Merkel. Wind farms are currently very much in focus in Germany and hence the case studies in the form of projects in Germany.

The PBL/PBBL element in the curricula appears in the fourth term as indicated in Fig. 6.

Fig. 6 PBL/PBBL approach in the fourth term at JUAS

V. CASE PROJECTS IN TUC

PBL/PBBL elements in a course needs some form of collaboration with fellow students and with the SIA-triangle model also between students, staff in the academia and experts in the industries, possibly involving the usage of dedicated hardware/software encountered in the project. As a group, one learns a lot more than as an individual, particularly in most of the engineering disciplines. The knowledge levels achievable in different learning scenario are schematically presented in Table 4.

TABLE 4
KNOWLEDGE LEVELS (SCHEMATIC)

Achievement (Knowledge) Level	Level
Level achievable when the student collaborates with someone **(LEVEL 3)**	
Level achievable when the student works alone **(LEVEL 2)**	
Present Level **(LEVEL 1)**	

A closer tie to the industrial partners usually enhances the performance of all three members in the SIA triangle of Fig. 1. Interesting aspect of the SIA golden triangle is that the process has a tremendous synergy that the level enhancement is mutual in a positive SIA working relationship. The benefits of co-operative learning are discussed in [2, 3] and our belief is that these benefits are not only at individual student level but also at the level of organisations.

A. Case projects at TUC in Spring Term 2013

We give the list of case studies we took up in autumn 1999 in collaboration with different industries as part of a PBL/PBBL environment. The students discussed the problems with the teacher, the lab-engineers in the university and the technical experts in the various industries. The students following the lectures were all 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 5.

CASE PROJECTS TAKEN UP FOR THE SUBJECT "SOFT SENSORS"

Company	Project
Ulefoss Jernverk	(1) A study of sand mould Anomalies
Ulefos Jernverk	(2) Detection of Molten Metal Freezing in flow of smelts
Emersons Process Management	(3) Usage of DCS based on DELTA V for control Processes

We look into one of the projects in Table 5, viz. case (1): Production Optimisation involving sand moulds used in metal casting of objects ranging from manhole covers to engine blocks . This project was collaboration between the TUC and Ulefoss Jernverket. The results from this PBL/PBBL assignment have been found to be of possible usage for process improvements at Ulefoss Jernverk.

Fig. 7 and 8 show two different processes controlled and run using a Distributed Control System (DCS) based on an industrial DCS program called DELTA V of Emersons Process Management. In conjunction with these projects, the students were directly in contact with developers of Emersons Process Management and industrial users of DELTA V to test out some new technologies. This process was a typical win-win scenario for all parties involved, including the developers, particularly in getting the hardware/software integration to function.

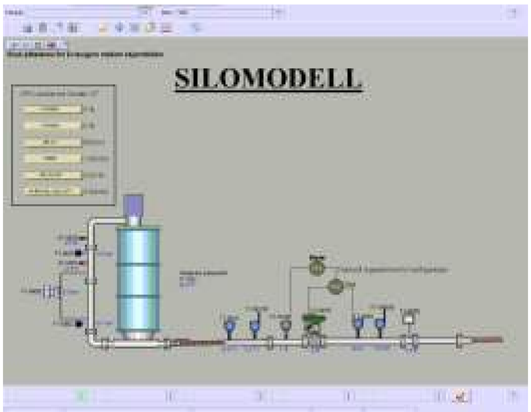

Fig. 7 Distributed Control System (DCS) for process control of powder flow in three hopper silos using DELTA V

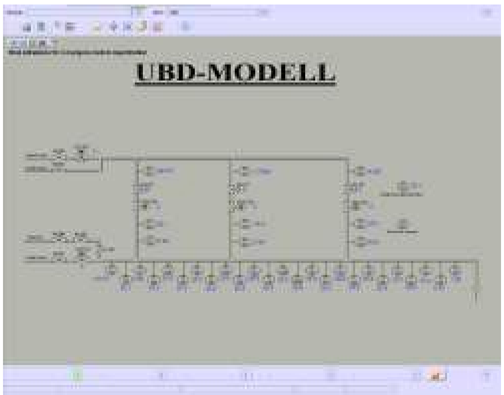

Fig. 8 Distributed Control System (DCS) for process control of a rig emulating some features of Underbalanced Drilling (UBD) with a plethora of networked sensors (both wired and wireless) for monitoring temperature, pressure, flow and acoustic emission.

B. Agile teaching methods

Various teaching methods are used in the instruction: classroom teaching, laboratory instruction, and the use of computer tools. The Bachelor's and Master degree programmes at the Faculty of Technology is project-oriented in that many of the courses are conducted as projects. This pedagogical method gives students greater responsibility for their own learning as well as experience with problem analysis, seeking information, contacts to industry and industrial actors and problem solving. Work is done in groups, often in close cooperation with local industry.

These study programmes use several different forms of assessment: examinations, projects, laboratory exercises and assignments.

In addition to purely project oriented courses, PPBL is closely integrated in other courses as well. PPBL is in use in most of the courses at TUC, but at different levels and with different weighting.

Table 6 lists some of the courses with highest PPBL weightings.

TABLE 6.

PPBL COURSES AT TUC WITH HIGH PBBL WEIGHT

Course Code	**Courses & PBL/PBBL**		
	Topic	**ECTS**	**PBL/PBBL or related weight**
EE4107	Cybernetics Adavanced	5	50%
EE4209	Model Based Control	5	50%
SCE4206	Systems and Control Laboratory	5	70%
IA4412	System/Software Engineering	10	70%

Traditional teaching methods contain a large number of ordinary lectures followed by pen and paper based exercises. Sometimes the lectures are followed by laboratory work or a small case project at the end of the semester. In the other end we have project courses where there are no lectures at all, only much larger and more practical assignments the students shall tackle on their own and hand-in written reports at the end of the course. As a rule, these assignments have contents involving hardware and software.

A pertinent question posed by many students and staff is: Is this the optimal way of teaching? These traditional methods offer very little variation.

Agile methods (in comparison to the more traditional waterfall approach) have become very popular in modern software development today. Why don't the students/staff use these modern methods in an education environment such as a University or a University College? In fact such methods can be easily incorporated in workshops dedicated to software development.

In Figure 9, we see different teaching methods. We see how this new approach differs from the more traditional methods. It is more flexible and offers larger room for more variations in scope and content for the students and staff.

This new approach based Agile methods, leads to more active/innovative students because there are few ordinary lectures and more focus on PBL/PBBL. In fact, the Agile methods can be classified as student centred teaching/learning methods with great potential for enhancing learning outcomes.

One of the most popular Agile methods today is Scrum. Agile methods such as Scrum have less focus on documentation.

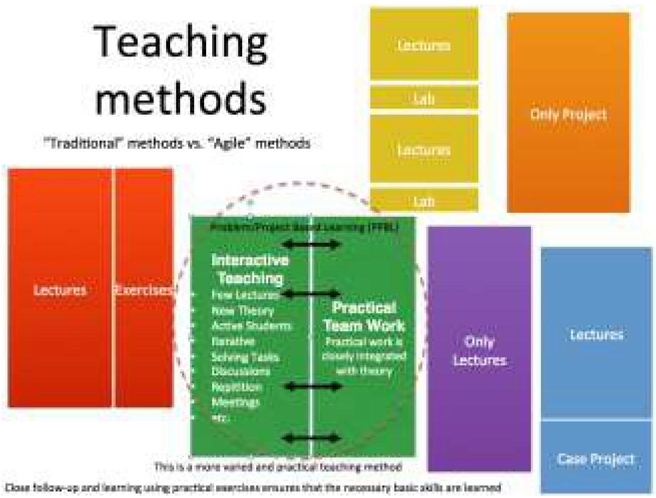

Fig. 9. Teaching methods: Traditional lectures/exercises vs. agile methods

Agile is a group of software development methods using an iterative and incremental approach. The software is available to customers every 2-4 weeks for inspection. The approach is based on self-organizing and cross-functional teams. The interdisciplinary approach creates a real working environment involving many actors as shown in Figure 10.

Fig. 10. Teams and different roles involved showing interdisciplinary nature of the PBBL approach based on agile methods, here using Scrum

The Scrum approach offers a more flexible way of education with more opportunities for hands-on experience during the learning process. It is a practical approach with less focus on documentation. It is well known among the staff as well as among students, that too much documentation is especially a problem among bachelor students. This is not a way of bypassing the need for learning to create and work with documents, but a choice to create a learning environment more amenable for all the students in need of acquiring professional skills. The ability to work with and create documentation can usually be tackled in dedicated courses elsewhere in the curricula.

In Figure 11, we see the Scrum approach used within a teaching environment.

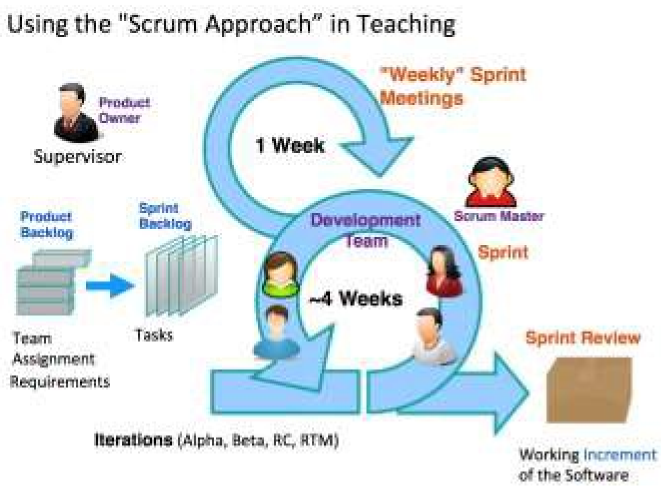

Fig. 1. Scrum approach used in teaching involving strong elements of PBL/PBBL approach. Note that the supervisor (teacher) is the product owner.

Although Agile and Scrum are primarily used within software development, it can be used as an ordinary method for project planning and tracking in most of the courses by properly tuning each activity for a particular course.

In Scrum, the work to be done is divided into iterations lasting between 2-4 weeks (these iterations are called sprints in Scrum terminology). During the iteration the team members have short and regular meetings to make sure that the project is on track. At the end of each iteration, the results/goals are reviewed and discussed together with the stakeholders/customers. Then the next iteration is planned, and so it goes on until the whole set of iterations is finished.

C. Learning by doing

This exercise of learning by doing implicitly involved in PBL/PBBL, gives the students many positive challenges and opportunities because of the following points:

- Learning to work in groups.
- Students were given various tasks in collaboration with the industry, thus learning the communicating methods used in the industry.
- Students had to learn about the industrial process and environment
- Students had to follow industry procedures in handling chemicals, materials and equipment.
- Students had to be creative and find solution to their problems and choose appropriate sensors, having the technical and economic aspects always in mind.
- Some of the students decided to run some tests, just to verify that their solution worked
- Write a report.

The most positive aspect with this "learning by doing" with this kind of project is that the 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.

D. Motivation in PBL and final examination

The set of goals of the project in the context of PBL were: 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. 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 lot to do with 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 eager.

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.

VI. Y-Vei and Student Enterprise at TUC

A. Y-Vei at TUC

"Y-Vei" (Y-path, Y stands for "Yrke" – ~Vocation) is a Norwegian word indicating a path to higher education in Universities or University Colleges based on formal vocational training with adapted training in subjects like Mathematics and Physics/Chemistry in the respective universities before admitting the candidates with vocational training to higher studies. The Y-vei is a specially designed study programme for students with trade certificates / apprenticeships making the path to bachelor or master degrees in selected fields appropriate to their vocational training. . During 3 years, these students can achieve a bachelors engineering degree and if they choose to do so, they can continue to study for a master degree following a 2-year master programme in their specialities.

This model was practised in TUC for a long time and has been very successful and the candidates are very often valued highly by the industries, particularly because of their experience with PBL/PBBL based education at TUC. Although the terminologies PBL/PBBL are not explicitly used in all the courses designed for the "Y-Vei" students, all the group based projects are very often based on PBL/PBBL approach.

In conjunction with a course on "Measurement & Instrumentation", although involving some challenges, a combination of "Y-Vei" students and ordinary students coming direct from the secondary schools in PBL/PBBL based projects helps to enhance the learning outcomes for the "ordinary" students as well as for the "Y-Vei" students, as they have the role of imparting their practical knowledge to the others without much practical experience. In addition, the strategy of enrolling "Y-Vei" students tallies with the EU vision of accomplishing LLL (Life Long Learning) in most of the technological disciplines.

B. Student Entrepreneur at TUC

Within the European Countries, there is a collaboration and competition in conjunction with "Young Entrepreneurs". This is a concept used in educational environments to motivate innovations and entrepreneurship. Usually, the students start with a concept based on some novel concept focused on new product development and innovation with a definite goal of establishing an enterprise at the end. The students go through all the steps involved in establishing an enterprise including economic planning, IPR-studies, handling personnel placements in the initial phases of the establishment of the enterprise. In such EU-competition, the "Y-Vei" students with or with some participation of "ordinary" students have always in the competitions nationally and at European level, many time winning the first prize. This overwhelming performance of the "Y-Vei" students is partly to be attributed to the PBL/PBBL approach they have in their curricula.

VII. AVOIDING PITFALLS AND FRUSTRATIONS

In using a PBL/PBBL based learning environment, it is mandatory that all the practical aspects involving hardware/software are well checked and available/functional. Any small "hiccup" in either hardware or software can create frustration and loss of motivation among students and coaching staff and lab personnel. In fact, in a case like the one described in Fig. 8, involving a plethora of sensors and actuators, any one unit failing can put a stop to the whole project. Some sensors and actuators may need weeks or months for replacement/repair and can hence lead to termination of planned activities, which is very problematic for the students and staff. A good rule of thumb in planning PBL/PBBL activities is that enough replacement units are in storage of all the sensors and actuators and all software used are with the necessary support from the vendors. This observation is narrated here due to some personal experience of the authors of this paper involving hardware failure involving the flow loop described in Fig. 8.

VIII. CONCLUSIONS

PBLPBBL based curricula in engineering curricula in collaboration with the industries are found in many universities, as are the cases from two University Colleges in Norway and one in Germany. Encouraging the student involvement in the selection of topics right from the beginning using the SIA triangle and facilitating PBL/PBBL in relevant subjects can help to improve the learning process tremendously. The PBL/PBBL case projects conceived in collaboration with the industries for the evolving course content in an engineering curriculum in close collaboration with the academia and the students are fruitful for all involved and can even lead to innovations, which can lead to new enterprises, as the case studies involving the "Y-Vei" students of Norway show.. The PBL/PBBL based learning are dynamic and helps to eliminate 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/PBBL arrangement and the establishment of enterprises are very much dependent on the interest and energy flow in the SIA triangle. Formalised agreements at the top are not enough to gain 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 curricula and attractive engineers to the society as a whole.

The success with "Y-Vei" students predominantly working with ~PBL/PBBL based curricula endorses the importance of this approach in most of the engineering curricula.

Experience shows that a dedicated course to the teachres involved in PBL/PBBL based activities can improve the quality of work and the learning outcomes. In addition, the holistic planning of course with and without PBL/ PBBL is of paramount importance to avoid unnecessary problems and at times even frustrating events impeding the progress of the planned work.

IX. ABBREVIATIONS

PBL	Problem Based Learning
PBBL	Problem/Project Based Learning
BUC	Bergen University College
JAS	Jade University of Applied Sciences
TUC	Telemark University College
LLL	Life Long Learning
Y-Vei	Yrkes Vei – Students following bachelor studies based on their vocational training after some dedicated coaching in subjects like Mathematics, Physics/Chemistry

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REFERENCES

[1] K. Z. Øzerk, "Opplæringsteori og læreplanforståelsen – en lærebok i pedagogikk", Oplandske Bokforlag, 1999.
[2] M.L. Manning & R. Lucking, "The what, why, and how of cooperative learning". The Clearing House. 64: 152-156, 1991.
[3] R. E. Slavin (1988). Cooperative learning and student achievement. Educational Leadership. 47(4): 31-33, 1991.
[4] http://www-pors.hit.no/~sabam/index1.htm
[5] http://www.ils.uio.no/english/rose/network/countries/norway/norway.html
[6] http://www.ils.uio.no/english/rose/network/countries/
[7] http://www.ils.uio.no/english/rose/network/countries/uk-england/q-eng.pdf
[8] http://www.ils.uio.no/english/rose/network/countries/india-mum/report-ind-mum.pdf
[9] http://www.regjeringen.no/nb/dep/kd/dok/NOUer/2008/nou-2008-18/8/4/4.html?id=532049
[10] http://www.regjeringen.no/nb/dep/kd/dok/NOUer/2008/nou-2008-18/8/4/4.html?id=532049
[11] http://www.niedersachsen.de/master/C4987619_L20_D0_I731_c36356208.html (Niedersächsische Landesregierung (Hochschul-gesetz))
[12] http://www.schure.de/22210/nhg.htm(Niedersächsisches Hochschul-gesetz)
[13] http://www.fh-oow.de/fbi/studium/e/ (Studiengäne im Bereich Elektrotechnik/Informatik)
[14] http://www.fh-ow.de/fbi/studium/pruef/Praxissemesterordnung.pdf (Praxissemesterordnung 5. Semester)
[15] http://www.fh-oow.de/fbi/studium/pv/ (Studiengänge im Praxis-verbund)
[16] S. Mylvaganam, et al, B "Innovations Based On Interaction Between Students, Industry and Academia: Case Studies from PAL and Learning Laboratories", International Conference on Engineering Education 2000, Taiwan