

Survey of PBL in the Norwegian Engineering Education: Brief History and Status Quo from a Selected Number of Educational Institutions

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Abstract: The usage of interdisciplinary projects and Project or Problem Based Learning (PBL) found increasing resonance and acceptance in many of the educational institutions in Norway for more than a decade. In the universities and colleges in Norway, PBL was used also in the teaching of engineering subjects. There has been some reference to Telemark model in earlier ICEE publications. This paper looks at the earliest applications of PBL in Norway and compares them with the status quo of PBL in the Norwegian academia. In the course of increasing acceptance of PBL, its practitioners experienced a series of pitfalls and tried to remedy them as they moved on. The paper presents the evolution of PBL, not only in engineering education but also in secondary schools in Norway, where the inclusion of PBL is revolutionising the methods of teaching. The paper also looks at the status quo of PBL, which is undergoing radical changes due to the inclusion of Internet as an integrated part of educational resources.

The paper also includes a futuristic scenario for education based on the new resources and PBL.

Keywords: PBL, interdisciplinary projects, comparison of learning environments

1. Introduction

This paper discusses the inclusion of PBL in engineering curricula as practised in Norwegian higher educational organisations. In traversing the path to formalised PBL in schools and higher educational organisations, we look into the evolution of PBL, and present the views of teachers and students on the use of PBL.

The medical faculties around the world have used PBL. Within Scandinavia, Roskilde University (RU) and Ålborg University in Denmark have established a tradition of using PBL. Ålborg University is considered as a trend-setter for PBL. In RU, all students go through a problem based basic education independent of the selected field of studies (social sciences, humanities or physical sciences). In Norway, Telemark University College (TUC) has strongly supported project work with interdisciplinary features from 1982 onwards in the Faculty of Technology, and in Bergen University College, PBL has been practised since 1992 in the Department of electrical engineering.

2. Project Based vs. Problem Based Learning

Traditional learning environments were obsessed with problems with well-defined solutions. In Problem Based Learning or Project Based Learning, the answer may not necessarily be unique. Table 1 shows the main differences between problem and project based learning. In many academic institutions, from an administrative point of view, either form of PBL is seldom a mandatory requirement and as such receives no formalised support. Where PBL is practised, it usually involves students and/or teachers with strong views about its positive aspects.

It is well known that the Faculty of Technology in TUC has formalised PBL based interdisciplinary curricula, and has been included in comparative studies of educational systems with and without PBL in various institutions in Norway. PBL per se necessitates increased involvement of the teacher and requires administrative support. The faculty members should have a common understanding and approval of the strategy for the implementation of PBL. However, the measurement of student performance could prove difficult in PBL, and should be pre-determined.

Table 1. Problem vs. Project Based Learning. Some differences

Problem Based Learning	Project Based Learning
Small in content and workload	Usually bigger in content and workload and more time consuming
Starts with a problem and should end with a solution	Process and results are important, and lead to different options for achieving the goal.
Focus mainly on learning	Focus on research strategies and group work
Could be a single person's work	Usually group work

3. Experience with PBL in Norway

3.1 Secondary schools: positive and negative aspects in group work – A student's opinion

The following is a direct excerpt from a student's report on PBL assignment, on request. It is included due to its relevance in any PBL based curricula in the context of secondary or higher education.

“Project is a group work; it is an essential part of education and school systems emphasise that students should have an opportunity to work with other students in a team. It is of vital importance for students to co-operate with others, so they can manage successfully, later in life. Working together with other students can be either a pleasure or a nightmare. Students have different personalities, and it is not always easy for teachers to facilitate friction free co-operation among all the students working with different projects. It is not easy for some students to co-operate with others. It can be both a source of worry and annoyance to have a partner one simply cannot work with. Being in GCSE now, I have had several encounters with group work, some successful, others not. I have considered what went right and what went wrong in different situations.

The first time, I was ever introduced to group work, was in fact as early as in kindergarten. We were in groups of friends, and were asked to draw pictures. I have been introduced to various types of group work during the years, but it started seriously when I was in the 7th grade. We had group works in many subjects. The group leader distributed the work, and each person worked with the given assignment, discussed it in the group and summarised the work. My first group work went quite well. The interesting thing in group work, is what happens when one is doing it. My friend was a typical "leader" type, and I was the follower. This functioned well, as both of us contributed our due share to the assignment. My friend was very devoted to it, and many times I found myself being told to pull myself together and to do something. We submitted the work and were praised for it. The next group work I remember was in the 8th grade. We were four friends working together. The co-operation this time was slightly more tensed. When we had been given the subject to work on, one girl jumped headlong into dividing work among us, at once. She took almost all the work, and gave us very little to work on! After her proposal (which really was more like an order), another girl, with a rather firm character, explained that this was not acceptable, as the work should be distributed equally among everyone. The result was again, quite good, but the whole work didn't go as smoothly as it did before. In another group work, I was in a group with all my friends. This turned out to be a practical joke. Everyone was fooling around behind the teacher's back and the few who tried to get something done, were called "school nerds". This was partly due to the teacher's loss of control and an appalling indifference to the evolving situation. Yet, in another group work in the 9th grade, I was appointed as the group leader. This turned out to be the best group work, I ever had. We were 5 in the group and 3 of us were very much involved. The others two were not so interested, but were encouraged to participate and they complied. I was sometimes told that I was a bossy group leader, but we still remained friends. Despite different levels of engagement, all of us contributed, creating quite a masterpiece. When something didn't function, as it should, we all felt it. When something finally did happen, and we found something worthwhile to write about, we were all overjoyed. We were members of the perfect team. The good thing was that we didn't let the group work affect our friendship, even if we had different views. The next group work I recall was a less successful one. We were two people working on a subject. It started extremely well, when both of us came with some brilliant ideas. We didn't exactly work together after we divided the work. The time for the work was limited and this is where the problems started. My partner simply didn't make any effort to do anything. No matter how much I tried, I couldn't persuade her to do her share of the work. I did my share and had to worry about hers! The real nightmare came on the cut-off date. I had been up until late the previous night, writing my part, but my partner turned up that day, without any written report and had only 2 hours left of the 2 weeks she had been given. We were in a state of despair and she asked me to help her. I tried my best because I didn't want to postpone the submission. I knew very well that this would affect my marks as well, no matter how hard I worked in those two hours. It ended

up with my writing half of her work. Although her knowledge of the subject was reasonably good, she worked slowly and postponed writing.”

This narrative reminds us of what experienced teachers call as “free wheelers”, “free riders” and “free surfers”. The interesting aspect of this episode is its portrayal of the advantages and disadvantages of PBL in a simple and illustrative manner. The advantages and disadvantages of PBL are shown in Table 2.

Table 2. PBL; positive and negative aspects of group work

POSITIVE ASPECTS	NEGATIVE ASPECTS
Students learn to plan their own work, to do relevant research and organise their work. It usually turns out to be enjoyable, if the students can select the theme, plan the activities without being told what to do by the teacher. Students face the challenge of organising and distributing work in a fair and just way and learn to be responsible for their own actions. This gives them a feeling of independence, responsibility, and fulfilment. 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. Under these circumstances, the teacher should take special care that the student finishes the project successfully and satisfactorily.
Students get the pleasure of exchanging ideas and motivating each other. Each student could be creative in different ways and this leads to interesting and impressive joint efforts. If a person is stuck, he/she can get help and support from others in the group, and they can solve the problem together.	In a group situation, you are forced to be dependent on others. It can be quite exasperating for a devoted student to be in a group where the others simply do not collaborate/contribute. It’s the ideas shared that create enthusiasm among the students and lead to better performance in group work. If a group member is not co-operative, the work would suffer and this member might be presented with undue credit, based on the others’ diligent work. Occasionally, a group with only friends is not productive, as the temptation to be idle might be strong.
Students develop more interest in the subject when they have to organise their work and carry out the research themselves. Students learn more in a project, where they have to do all the research themselves. This knowledge is not easily forgotten, whereas some of the information one otherwise learns at school is easily forgotten.	Students might not learn much during the project, either because they do not plan, organise and carry out the project successfully. If the teacher does not provide appropriate support or delivers a cook book recipe like instructions to the students, boredom, indifference among students and bad performance will result..
Students learn to plan and to follow the plan and time schedule, to submit the results/conclusions at/before the specified time.	If students are unable to fulfil the project satisfactorily, a sense of frustration and failure results, which may jeopardise the studies
Students learn how to interpret different kinds of information sources, and to filter out reliable information. Students get a chance to show their creativity, not just repeating what is in the book	Different information sources can easily confuse students and the result may be that the students really can’t get a grip on the subject.
When the members of a group co-operate and contribute effectively, the outcome is generally better than that of individual efforts.	When members in a group have conflicts and are unable to compromise, the results might not be good.
The student gets some training for work situations and learns to co-operate with different people. One learns about constructive criticism and compromises.	Co-operating with people with different personalities could be annoying and stressful., but also bad marks, and certainly bitter feelings. Personal conflicts and strained relationship might develop.
Students get a good preparation for later life; they will not always have their teacher to “feed” them with relevant and timely information	Students who do not fulfil their projects satisfactorily, may develop a feeling of inadequacy, also in later life.

3.2 Teacher Centred Learning (TCL)

TCL has been practised for many years and was regarded as an ideal method. This can, however, be limited in some aspects; it does not provide opportunities for the students to be creative or responsible. Students should be able apply the basic knowledge learned from the teacher and to get further relevant information or work out strategies for solving problems. This is what occurs in project works. This is where the student takes the responsibility and the teacher becomes the supervisor. TCL and PBL have different teacher-student relationships. The teacher is a reliable and experienced person to learn from. However, the students’ success is dependent on the teacher’s capacity for making the students understand his teaching and motivating them. In extreme cases, the students may even drop out of their courses. A good teacher should control the work of pupils and not burden them with unnecessary work.

The same narrator from above continues:

“My idea of a perfect school system, would be where it combines teacher-student classes with projects based on practical problems. This would stimulate students and make them interested. Project is, in some ways better than teacher centred learning; students learn to be independent, and often remember information got via a project better than copying something off a blackboard. This is definitely not a reason to base teaching only on projects. Teacher centred learning is popular and in many ways good, as the information given is always reliable and often include the necessary basics, which are required for solving practical problems. This aspect, is very much dependent on how good the teacher is.”

3.2 University colleges and universities

The professionally oriented colleges have tried one or the other form of PBL. The universities with their curricula dedicated to more individualistic performance of students have in the past not been very enthusiastic about PBL. However in the recent years the PBL mechanisms are discussed and applied in different disciplines also in the universities in Norway. Due to space restrictions, we limit our discussions to the PBL applications in engineering education at the university colleges. It is noteworthy that the medical faculties have a strong tradition of using PBL in some of their curricula.

The report [1] describes the use of PBL in Norway and emphasises the interdisciplinary nature of PBL in TUC. For purposes of comparison of the engineering curricula in Norway, the predecessors of TUC (earlier called as Telemark Ingeniørhøgskole), Trondheim University College (Trondheim Ingeniørhøgskole) and Bergen University College (Bergen Ingeniørhøgskole) were studied. According to this comparison, the PBL approach at an institutional level was promoted by TUC from as early as the 80s. The students of TUC in the engineering curricula found the interdisciplinary nature very attractive and relevant, and voted for TUC as the best place for studies. In the evaluation of the student performance, based on average marks in engineering curricula in all these institutions, indicated, however, that TUC students did not score better than their peers did in non-PBL organisations. The author concludes that the form of study has a strong influence on the level of satisfaction shown by the students in various academic organisations – an observation which tallies with the opinion expressed by the secondary school narrator mentioned above. Workload has been observed to be high in organisations practising PBL. The PBL adherents found out that the students had better contact to the teachers. In compliance to the others’ views, the PBL, which gives the students a scenario similar to those in working environments motivates the students. The students take this as a challenge and try to work with the projects in groups and very often deliver interdisciplinary and workable solution. This might be the reason for their satisfaction during their studies in TUC. The PBL approach introduces different aspects in teaching-learning process, which are difficult to achieve through traditional methods. Table 3 summarises the various issues during study, further education and employment situation after leaving the university colleges. The higher the number of crosses in a particular column, the greater is the tendency of the item allocated to that column.

In PBL with projects defined in conjunction with the industry, the industrial colleagues are usually satisfied. However, there have been frequent reports from some industries, of insufficient basic knowledge of some PBL students. PBL students from Norway and pursuing higher studies in the USA, very often get high credits in the American Universities, according to some observers.

Table 3. A general overview of traditional teaching/learning vs. PBL. The number of “+” is an indication of the particular factor under scrutiny and is purely qualitative. These observations are based on a comparative study within Norway, [1].

TYPE OF EDUCATION	DEGREE OF SATISFACTION	GROUP WORK	EXAM PERFORMANCE MARKS		HIGHER STUDY PERFORMANCE	EMPLOYER SATISFACTION	
			Genuine student	Free Rider		Group work	Independent work
TRADITIONAL	++	++	++++	+	++	++	+++
PBL	++++	++++	++	++++	+++	++++	++

4. Critical view of present day evaluation of student performance

A problem at the end of PBL, will be the assessment of the performance of individual candidates. The parameters (x_i, w_i) shown in Figure 1 are dependent on various assignments including PBL with a pre-assigned weightage w_i satisfying $\sum_1^n w_i = 1$ and $x = \sum_1^n w_i x_i$ with $w_i < 1, x_i \leq 10$ in a marking scheme with 10 as the upper limit.

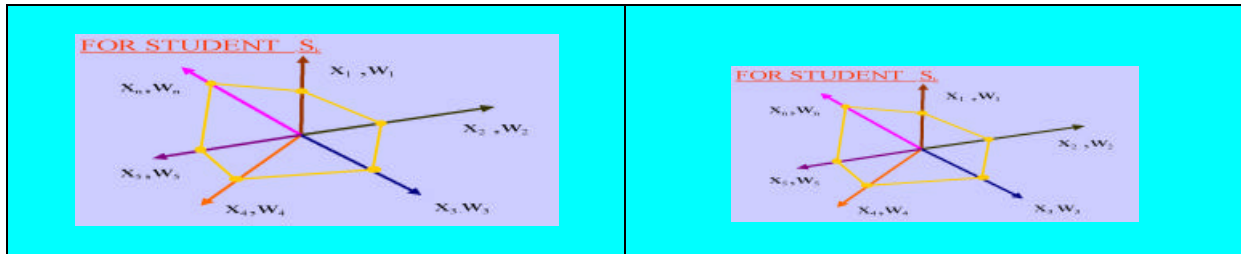


Figure 1. Performance of student S_k based on many different forms of assignments during the course of a semester. The values (x_i, w_i) are the points for each assignment and weightage of an assignment for a given subject. The left and right figures are meant for two different students in the same class with two non-identical (x_i, w_i) . n represents different assignments.

The pair of values (x_i, w_i) can be in general terms selected to match the seven form of intelligence discussed in [2] for a particular student. We even look into the possibilities of varying the pair of values (x_i, w_i) for students S_k and S_l in the same class simultaneously in the same semester. The process of developing an evaluation scheme emphasize the need for the teacher to develop a teaching strategy catering to the needs of each student in the group so that at the end there will be a general improvement of knowledge in the subject.

The Open University (OU) in UK has many innovative means of evaluating student performance. OU uses in some subjects 7 TMA (Tutor Marked Assignments) and 8 CMA (Computer marked Assignments). Continuous assessment score (CAS) is obtained by weighing TMA, 70% and CMA, 30%. In addition, Exam Score (ES) will be taken into account. In some courses there is a substitution scheme. For each student, TMA can be substituted as follows: The average of CAS and Exam score (ES) are worked out. This is the substitution score (SC). If any TMA mark is below this average SC, the lowest TMA mark is replaced with SC and the CAS is recalculated. Thus, the pass grade is a function of the CAS.

The weighted average would depend on the category we want to classify the student under. Alternatively the teacher could use a bar chart type of presentation with different subjects along one axis and the marks along the other axis. The overall shape of the bar chart may then be used for classification purposes. There would always be some people who would not fall into these categories, because these are in some ways arbitrary, and human beings, being not machines, would never fit into rigid frameworks.

The performance evaluation is a function of teacher's involvement, quality, the subject matter, the relevant innovations and how these are integrated, and the student performance in the different parameter sets shown in Figure 1. We see a need for paradigm shift in evaluation form and methodology to judge each student with his/her special abilities. The shoebox thinking of having each subject separately is faulty in the context of evaluation performance with the student's "smart spectrum" de-coupled from these evaluation algorithms, however simple or complicated these may be. In the Norwegian scheme of marking with an uncertainty of ± 0.1 , the numerical marking scheme leaves us with a paradox.

5. Future scenario

There are many signs of some PBL practitioners reverting to the traditional methods due to "free-rider survival" in PBL based studies and evaluation. We believe that the fault is intrinsically with the teacher and the administrators and not with PBL, who should attempt to improve the PBL and students' performance evaluation, and follow-up, feed-back information, from both student and the industry. Special attention should be paid to avoid "free-riders" leaving the university colleges or secondary schools with certificates they don't deserve.

Cross-border multi-linguistic PBL conducted using internet between Italy, Greece and the UK, at even kindergarten level is being viewed as successful within the EU's Comenius programs. We believe that the present day slowdown in the usage of PBL is a transient phenomenon in certain sectors, and also that a 100% PBL replacing the traditional

teaching-learning process is educational puritanism at its extreme. A model with different types of assignments with increased teacher-student interactions with greater involvement of student assistants and tutors will become a flexible and attractive model, seen from the perspectives of the students, teachers, administrators, industries and society as a whole.

6. Conclusions

The focus is on the merits of PBL as compared to the shoebox approach to education. The approach using PBL promotes interdisciplinary thinking and a wider perspective of the subject matter. Project work, with its associated studies, analysis and report gives a broader experience to the interested students. With the guidance of the supervisors students are trained to tackle group dynamics in achieving set goals, as they will have to do in their work environment. There is also a strong coupling between teaching and research.

Our experience shows that the PBL approach helps the students and the academic organisation to have a vigilant eye on the time frame, which in some university curricula tends to vanish, creating a series of critical discussions in the upper echelons of the ministry of education. In addition, the problem of free-wheelers and students passing out of schools and higher educational institutes have started a series of criticism of purely PBL environments. The students, academia and industries should take this as a challenge and innovate methodologies to prevent free-rider survival through the educational process. We think that in the future, the model of evaluation basket involving tutorials, laboratory assignments, conventional examinations (either oral or written or both) should be supplemented by PBL, [3]. In addition, it would be advantageous to start PBL at schools, and certainly practice it at the level of Upper High Schools, in collaboration with the universities/colleges, according to the students' interests. Such collaboration will also help to increase the number of student applications to science and technology oriented higher studies, and to eliminate the currently existing artificial barrier between the schools and higher education institutions.

7. References

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8. Miscellaneous

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