# Mechatronics in the technological innovation and entrepreneurship program


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***Abstract*** *— A new bachelor in technological innovation and entrepreneurship was established at Østfold Technical College in 2003. This was the first bachelor of this kind in Norway. The external attention and expectations from the society was large.*

*The overall goal with this study is to educate students to be entrepreneurs, with the knowledge, skills and attitudes needed to succeed. Further there was a large diversity among the students related to sex, age and knowledge within mathematics and physics. On this background it became clear that new and efficient teaching methods had to be used to succeed.*
*This paper presents a new model for use of cases in a multi – disciplinary design project from organizational -, management - and cultural perspe ctives, use of different learning arenas and creating teams of teachers for one topic.*

*During the last decade there has been a gradually shift from ordinary class room teaching, where the knowledge was transferred in one direction from the professor to th e students towards Problem based learning (PBL), a totally new approach to education and learning, which is especially important in the education of entrepreneurs.*

*The use of problem based learning is illustrated in five cases from the Mechatronics cours e, which is a 25 credits (European Credit Transfer System) course, taught the first year in the bachelor program. The cases presented are: Lego Robolab, ScienceCamp, Bridge Prototyping, Robotics and Rocket Case.*



***Index Terms*** *— Innovation and entrepreneurs hip, Mechatronics, multi -disciplinary, Problem based learning, culture, management, organization.*


## INTRODUCTION

Autumn 2003 Oestfold University College started up a bachelor program in technological innovation and entrepreneurship. This was the first bachelor of this kind in Norway. This College has got a very central position in this area within the university colleges and universities in Norway due to a large activity within this area from 1994.

The background for the study in the region Oestfold was an increasing need in Norway for more jobs to be created in the future, as the traditional industrial branches have decreasing number of employees. It was a great demand for entrepreneurs in new and existing businesses.

The bachelor in innovation has as an overall goal to:

- Train students to be result oriented and independent.
- Give ability to tackle challenges and to work under pressure
- Give competence to organize and manage innovation – and entrepreneurship in own and new enterprises.
- Give competence to efficient and independent learn new knowledge and skills.

The key competence Oestfold University College is aiming to give the students is: The right attitudes, ability to work under stress a large capability to take defeats and to be very persevering.

The profile of the study is illustrated in the figure below:

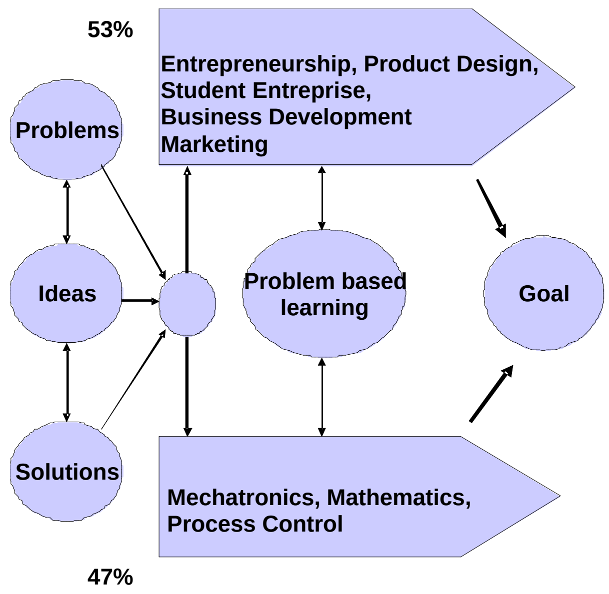


FIGURE 1
THE BACHELOR IN TECHNOLOGICAL INNOVATION AND ENTREPRENEURSHIP PROFILE.

## THEORY

Obviously good, effective teaching contributes to learning. However, a key question is what the relation between teaching and learning. Is there a general shift from traditional classroom teaching to more effective methods with focus on learning [1].

In the classroom the focus is very much on the teacher. In the preparation for the lesson the teacher may have identified some objectives for the session, but they are likely to focus on what he/she will do and the subject content that he/she will cover. The student has no choice over the content, the pace at which it will be covered, or when and where this instruction takes place.

What is wrong with that? Well it assumes that knowledge is something that can be transmitted and that can be accumulated in a linear fashion. It assumes that all the students will learn at the same pace, and it forces them to learn in the same way. A variety of learning theories, if not common sense, would suggest that this is very wrong. Knowledge needs to be individually constructed by the learner [2]. Learners need to be actively engaged in the process [3]. Learners clearly have different learning styles, and do not learn at the same pace [4].

Many of the changes taking place have a greater focus on the learner than the teacher [5] [6]. For example:

- Varying pace, place and maybe choice of study
- Increased peer support
- Learning teams, electronic discussions groups, peer tutoring etc.
- More explicit training in learning, study skills, etc.
- Self and peer assessment
- Developing students own judgement skills.

A recent review in Australia has shown that learners who have more control over their learning are more likely to: be motivated, see the relevance of what they are learning and take a deeper approach to their learning [7] [8] [9].

The problem based learning method has sprung out from the above described trends in learning. It is common to define problem based learning as a curriculum and a process. The curriculum is based on problems that create a demand for knowledge, problem - solving skills, work in teams and adjustment of learning strategies. The process is based on a systematic approach to solving problems or meeting challenges [10].

Oestfold University College is using problem based learning principles throughout the whole bachelor in technological innovation and entrepreneurship, due to its strong belief that this method of learning is especially important for entrepreneurs, as the most common way of learning.

## CASES

***The Lego Robolab Case*** marked the beginning of the mechatronics course. The main goal was to introduce the new students to each other, teamwork and innovative use of technology.

The objectives for the case are to build and program an autonomous robot to compete in a speed race using the Lego Robolab [11] hardware and software. The different teams have three hours on the task of designing, programming and testing the robot. The work was assessed by the performance in the final race.

FIGURE 2
THREE STUDENTS AND ONE AUTONOMOUS ROBOT.

The Lego Robolab Case took place the first week. The different teams were chosen randomly and all students had to relate to new people of different age, sex and background. The work done by the teams were characterized by great enthusiasm and a wide diversity in competing models. A lot of the students showed skills in building using Lego probably based on earlier experiences. All robots managed to complete the race court after only minor adjustments.

The evaluation proved the case to be a success. The early exposure to practice and simple design working in teams were appreciated even so the basic concepts of PBL could have been more explicit.

***The ScienceCamp Case*** followed two weeks of basic physics and mathematics related to the case, taking place in a more traditional learning environment. The main goal was to develop further the skills required to work in a team on complex tasks and test the student abilities to take initiative and respond to changes. Further knowledge and experiences in PBL is emphasized. Along the general goals this case also include more traditional goals on knowledge about specific issues from physics and measurement systems.

The students took part in planning and implementation of a scientific expedition to study earthlights in collaboration with scientists. Core objectives were logistics (the base stations were on a remote mountain), continuous manning and operation of professional equipment in a hostile environment and responses to changes in climate, plans and objectives. Data from the expedition are used by the Hessdalen Project [12] in the search for knowledge about the earthlights phenomena. The students were assessed based on the work on location and a written report from the team.

FIGURE 3
BUILDING BASECAMP AT FINNSAA.

ScienceCamp took place first week of September. Two base stations were built on two different mountains overlooking the Hessdalen valley. The students were organized in three groups rotating between each of the base camps and our head quarter located down in the valley. The head quarter served the base camps on security and communications. We were operating and collecting measurements on key parameters like fluctuations in the electric and magnetic field and visual surveillance of the valley. The stations were manned and operative for three nights in a hostile environment by the students showing stamina and skills. Some students were unable to go to Hessdalen and administrated a web page reporting on the progress and status in the case from the university college. The expedition had visits by several journalists, including a journalist from a national German radio station.

From the student evaluation we can see that the expedition were a great experience for the students. The location, the scientific approach and the skills and knowledge gained boost the confidence. The importance and challenges in team work was noted by the students. Some students also noted a concern on the intensity and demands during the case. This together with the students staying home is a challenge for the next course.

***The Bridge Prototyping Case*** focused on statics and mechanics. The main goal was to develop further the skills required to work in a team on complex tasks and the knowledge and experiences in PBL. Along the general goals this case also include more traditional goals on knowledge about specific issues in statics and mechanics. The complexity in the case is increased and the time limit used increases the challenges working in team.

The objective was to design and build a bridge after a given specification in 48 hours. Key physical parameters are cost, building time and strength. The students are assessed based on the work on location and a written report from the team discussing calculations on strength in the model built.

FIGURE 4
TESTING STRENGT ON BRIDGE PROTOTYPES.

The bridge prototyping case took place last week in November and was the first hand on activities on statics and mechanics. In one week the different teams should plan (including calculations), design and build the bridge. Each team decided on materials and dimensions used keeping in mind the specifications. Three days were used for planning and two days for the actual building and testing. During this week the students had the opportunities to consult the teachers. All teams used this opportunity. Pictures and interviews with the students working on the case were published in the local newspaper.

From the evaluation the students emphasize the positive effect of close bounds between the case and the theoretical concepts taught. During the week the students had a very high workload (they planned the work schedule themselves) and in most teams there were conflicts within the group. Despite the conflicts the teams were strengthened. There were also questions on the criteria used in the assessment (there were some adjustments made last day).

***The Robotics Case*** focused on programming, system design and how to manage a complex project. The main goal was to develop further the skills required to work in a team on complex tasks and the knowledge and experiences in PBL. Along the general goals this case also include more traditional goals on knowledge about specific issues in programming and system design. The complexity and extent in the case is further increased and represent great challenges for the teams.

The objectives included building an autonomous and/or remote operated robotics. Using an Evolution Robotics ER1 kit [13] as a base the students built and programmed a full size robot for use in a complex scenario (chosen by the team) with movement, sensors, voice, sight and wireless communication. The students are assessed based on a demonstration held before a jury with external and foreign members in English and an individual paper based on a template from a scientific conference.


FIGURE 5
THE ROBOCOP SECURITY ROBOT.

The robotics case was organized in three phases from January to April, a total of 7 weeks work. First phase was an introduction to the base technology including the graphical programming environment and hardware design. The students built several simple robots to test out different aspects and planned the final robot from experiences made in this period. Second phase was dedicated to the actual building and programming of the final robot. The third and last phase focused on presentation techniques, writing skills and the final modifications. All phases used a combination of lectures, workshops and guidance. Writing a scientific paper was introduced and a workshop on reference techniques and tools were held by the library staff to improve the skills.

From the evaluation the students emphasize the positive effect of close bounds between the case and the software and hardware concepts taught. The freedom in design and presentation given in the case gave room for the teams to approach the objectives in different ways and all models went a long way from the basic ER1 kit and models from which everything evolved. Not every team managed to organize the project in a effective way and the workload was enormous for the most ambitious groups (but so were the learning). Problems and conflicts were present in every group but solved in a constructive way in most cases. The size of the teams where not ideal and should not exceed five students in later similar cases.

***The Rocket Case*** focused on physics and electronics. As in previous cases the main goal was to develop further the skills required to work in a team on complex tasks and the knowledge and experiences in PBL. Along the general goals this case also include more traditional goals on knowledge about specific issues in physics and electronics. The complexity is further increased since the teams now work together on the same project. There was no room for mistakes (only one rocket) and success was not only dependent on the teams, but also the rocket range crew working together with the teams.

The objectives included building the payload on a rocket for measurements (altitude, acceleration and rotation) in the atmosphere, calculate the rocket trajectory and landing area for the ballistic rocket and receive and evaluate the measurements from the rocket. The students are assessed based on work on location.


FIGURE 6
ANDOEA ROCKET RANGE.

The rocket case was run the first week in April at Andoeya rocket range [14] in northern Norway. The case was organized as a combination lectures, workshops and the building and preparing of the rocket led by specialists from The Norwegian University of Science and Technology [15], The European Space Agency [16] and Andoeya Rocket Range. Some students were unable to go to Andoeya and ran a weblog from the university college on the status on the project. Pictures and interviews with the students working on the case were published in the local newspaper.

From the student evaluation we can see that the expedition were a great experience for the students. The location, the rocket exploding off at accelerations above 50 G and the skills and knowledge gained boost the confidence. Again not all students took part and lost vital knowledge and experiences. Uncertainty on economical issues is a possible explanation. The students emphasize the positive effect of close bounds between the specialists and the work done.

## DISCUSSION

In this chapter the five different cases are compared (simplified) the following table, the using the keywords: goals, objectives, results and evaluations.

| Case | The Lego Robolab | ScienceCamp | The Bridge Prototyping | The Robotics | The Rocket |
|---|---|---|---|---|---|
| Goal 1 | Social. Introduction to cases and PBL | More complex cases. Larger groups | Work under increased stress | Complex and long time scale case | Complex cases with focus on collaboration between groups |
| Goal 2 | Technological self confidence | Physics | Statics and mechanics | Programming and system design | Physics and electronics |
| Objective | Build and program an autonomous robot | Build and run continuous measurements in a hostile environment | Design, plan and build a bridge prototype | Building a robot for use in a complex scenario | Build the payload and launch a ballistic rocket |
| Results | All robots completed the race after only small adjustments | Operative stations and great enthusiasm and stamina | All bridges met the criteria given. Theoretical concepts in practice. | A wide variety of solutions using very different approaches to the technology | A successful launch and a partly working payload. great enthusiasm |
| Evaluation | The case was a success. The basic concepts of PBL could have been more explicit | New and very positive experience Defection | Close bounds between theoretical concepts and the case Conflicts between groups | Freedom to design and innovate To large groups | Technological confidence Defection |

TABLE 1
CASE OVERVIEW

Looking back the following observations were done:

PBL is very much depending on working in groups and in teams. There was a hard work for all teachers involved to create good functional teams in the class. One problem during the teambuilding was an ongoing competition between members of the class. It was a clear tendency that the best students wanted to fill up whole teams and let the weaker students fill up other teams. This led to poor working conditions in the class, and a lot of heavy discussions. After some time this team structure was broken up. The students were asked to establish mixed teams themselves with 2/3 strong students and 1/3 weaker students, with the premise that the weaker students be taken care and helped by the stronger ones. Teams were established with these characteristics and with a good chemistry between the team members. This turned out to be the key to create good functioning teams. At the end of the year, all teams were working well internally and in a network between teams, solving complex problems.

The knowledge, skills and attitudes among the students were not checked out before initiation of each case, causing frustration among students and teachers. Further, The PBL method was not sufficiently explained to the students at an early stage. This resulted in less efficient work in periods among the students.

The PBL method was at the start working well for a small number of students. Most of the students had problems to organize their time and had either too small or too heavy workload in some periods of time, resulting in frustration and anger among the students

## CONCLUSION

When practising PBL it is important to check out the knowledge, skills and attitudes among the students at an early stage using methods as interviews, student CV, different tests etc.

It is important to prioritize the creation of good functional teams at an early stage, and be prepared that this will require a lot of work and attention from the teachers.

The PBL method should be thoroughly explained to the students at an early stage.

Practicing the PBL method requires a very good following up of the students from the teachers, to secure a controlled workload.

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