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A PROJECT FOR THE PROGRAMME OF INFORMATION TECHNOLOGY AT LINKÖPING UNIVERSITY

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ABSTRACT

The project is developed for the Programme of Information Technology and started in 1997. It consists of 30 ECTS credits, i.e., it covers the work of the entire autumn of the students third year. It includes both project works and individual examinations, half of each.

The aim is that the students will conceive and develop a technical system, consider the technology in its context and cooperate with students from LiU[1] School of Management and Psychology. They will work in a project organisation and gain knowledge about project planning and project management.

The subject areas involved are Business Administration (marketing and calculation), Computer Hardware and Architecture, Numerical Algorithms, Ethics, Psychology (group dynamics and group processes) and Communication (text revision and criticism).

The students are divided into project teams of 5—7 students from Information Technology and a project manager from LiU School of Management. Students of Psychology work as consultants and give professional support to the teams helping them to understand their own group process.

To implement these ideas the students are going to study the possibilities of constructing a mobile robot with one arm. They shall also study how to design a computer system with good qualities-in-use. The aim is to investigate and examine certain properties about the robot and the system, not to construct a manufactured product.

The students select and investigate a market area (examples: libraries, pharmacy, flight packaging, feeding cows) and design a computer system suitable for that area. They construct a small-scaled vehicle which is able to follow a marked track automatically. To control the movement of the arm they have to develop and examine numerical algorithms. They also examine the profitability and investigate and discuss ethical aspects.

The results of the investigation are reported to a customer in the form of oral presentations and a written report.

The advantage with this project is the large freedom for the students to choose their own business idea and the details of their studies. Thus every project has its own unique point of view.

[1] Linköping University

INTRODUCTION

The Programme of Information Technology, was initiated by Professor Ingemar Ingemarsson and started in 1995. An important part of the IT-programme was the project in the 5^{th} semester. I was engaged together with Professor Nahid Shahmehri at the Department of Computer and Information Science as responsible persons. Since 1998 I am the only responsible person. I am employed as Lecturer at the Division of Scientific Computing in the Department of Mathematics. I have responsibility for several courses in Numerical Methods and Numerical Algorithms.

In this paper I will describe the project from the beginning until today. I will start with a brief description of the IT-programme. After that the project is described, starting with the initial development and continued with individual examination, the organisation and further developments. At last I draw conclusions by listing the advantages and the disadvantages and make comparisons with the CDIO Standards.

A NEW PROGRAMME WAS STARTED

The Programme of Information Technology was initiated by Professor Ingemar Ingemarsson at the Department of Electrical Engineering. He wanted to have an alternative to the traditional way of teaching the students of the Master of Engineering Programmes. As it is very difficult to change established structures he thought that the best way of renewing things was to start from the beginning. This was a couple of years after 1990, a time of expansion and there was no problem to get means for the development of a new programme. Professor Ingemarsson and a team of interested teachers began to discuss and decide how to design the IT-programme, as the new programme was called. Some important principles could soon be established.

1. The knowledge base was going to be:

   - Mathematics
   - Computer Science
   - Electrical Engineering

   In addition the students should take one introductory course in Physics

2. The education should be based on Problem Based Learning (PBL). The inspiration came from medical education where PBL was established some years earlier.

3. The technology and the knowledge of a subject would not be isolated, the context was important and integration became a word of honour.

   - Written and oral communication should exist as a thread through all the education.
   - As a compliment to mathematical and technical knowledge the students should also get introduction to subjects such as Ethics, Business administration and Psychology.
   - The students should have possibilities to improve their knowledge of languages.

4. One semester (the 5^{th}) ought to consist of a project, where not only subjects were integrated but also students from other disciplines would participate.

5. The old programmes in Computer Science and Electrical Engineering attract very few women, which is a disadvantage. The teachers who developed the new programme tried

to have a gender perspective in mind when they designed the programme in order to attract women. The first years this was very successful and some years there were 50 % women. Unfortunately this is not so today.

6. The aim also was to admit students with a non mathematical/technical background to participate if they got supplementary training in mathematics during the summer. These students had difficulties due to their lack of physics and mathematical training. Many of them soon gave up, but a few succeeded to take their exam and appreciated this possibility to become an engineer. Due to the difficulties this attempt was discontinued after the first year.

The programme started in 1995 with about 30 students. At the same time the development of the 5^{th} semesters project began and Professor Nahid Shahmehri and I were involved as responsible persons. We formed a group of interested teachers who had the task to develop the details of the project.

In the next section I will describe the requirements we had to work with and how the project was developed.

THE DEVELOPMENT OF THE PROJECT

When we started to work with the development of the project we had some guiding principles and a preliminary syllabus, but otherwise we had the liberty to design the project in a way that was suitable for everyone involved. The syllabus with the involved subject was given and the subject areas were:

Computer Hardware and Architecture from the Department of Electrical Engineering.

Compiler Technology from the Department of Computer and Information Science.

From autumn 2003 Compiler Technology was replaced by Ethics (Centre for Applied Ethics). This change was done because the programme was partly modified.

Human Computer Interaction from the Department of Computer and Information Science.

Numerical Algorithms from the Department of Mathematics.

Business Administration from the Department of Management and Economics.

Psychology from the Department of Behavioural Sciences.

Communication from the Tema Institute

The subjects were chosen partly because they were convenient in a project environment (Computer Hardware and Numerical Algorithms) and partly because you could find interested teachers (Human Computer Interaction, Compiler Technology). One of the guiding principles was that the students would study technique in its context and also learn how the members in a working group could increase their efficiency. Therefore Business Administration, Psychology and also Human Computer Interaction were natural choices. Written and oral communication must also be included in a project. Furthermore, students from LiU School of Management and Psychology would participate in the project.

We built a team of teachers representing every subject involved. I had never worked in a similar group before so it was very exciting and a little bit confusing at the beginning. Our team met approximatively every fortnight. Rather soon we had got a few ideas accepted by everyone.

- An appropriate task for the students of Psychology is to help the project teams with their group process in order to avoid conflicts and make the teams more efficient. In that way the students of Psychology would get a good training for their professional career. The Psychology students would also come from the 5^{th} semester as it in that case very well fits their own curriculum. They have studied enough group psychology and in this semester every Psychology student would practice their coming profession. To work with the IT-students should be an alternative for some of them.

  The students of Psychology should not become members of the project teams, but would observe the teams from the outside since they can not perform a professional work if they are involved in the group process.

- The IT-students would study group psychology, to get basic knowledge of the structure and processes of working groups. As part of the project they had to analyse the development of their own team and compare it with the theory. To be able to do this they had to keep a group diary.

- To get applications in every subject involved, an automatic robot with a mobile arm would be suitable. The robot should be able to work in a warehouse or in a similar place with picking and packing articles.

- In Business Administration the students should investigate the market and make profitability calculations.

Now and then during our meetings, discussions about what a project really is, took place. Many persons thought that it was important that we had the same definition of a project work. But this was not always the case. The discussions were endless and we never came to a decision. For me this was very confusing since my naive knowledge of project was: "You have a task to solve, solve it". Some planning will perhaps be needed, but why so many complications. Some persons in our teem held a very strong opinion about the definition of a project. But the definitions were quite different for different persons. My conclusions from these discussions were that flexibility must be a principle of honour if different persons with quite different backgrounds should get a project suitable for their subjects. It is impossible and unnecessary to have an exact definition. When the project at last was implemented the reality gave a practical working guide and that was sufficient.

We soon realized that it is impossible for the students to construct a robot which is able to solve the required tasks in the time available. Furthermore the teachers had no time to prepare everything and the material would be too expensive. A way to solve this problem was to formulate the problem as a pre-study.

We invented a company, FAAB (can be associated with SAAB, the famous Swedish aeroplane company in Linköping), whose development department, FAABFUT, acts as customer to the project teams. The order to the teams is:

- Examine the possibility for FAAB to manufacture a mobile robot suitable for moving articles in a warehouse.

- Also construct a computer system for warehouses.

- Write down the results and the conclusions in a report.

This formulation also implies that every teacher took care of his/hers own part of the project. The connections between the different parts were rather weak. You can see it as an advantage, it was easy to implement and you do not need common rules and everyone can construct requirements suitable for their own subject. On the other hand it is a disadvantage that the

project is not one but several projects. But there is a connection since everything is needed later on when the production really starts.

A short description of the requirements for the different parts of the project follows:

Marketing Select and investigate an area, where the robot can be used. It must not necessarily be a warehouse. Contact at least one presumptive customer and make a field investigation in order to find out how big the interest in automation is. Modify the ideas to meet the desires of the customers. Make an analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT-analysis) and try to draw conclusions about the future market.

Calculation Estimate the price for the whole system. Use realistic figures as much as possible. Make profitability calculations.

Human Computer Interaction In order to design a system with good qualities-in-use, the requirements and desires of representative users must be investigated. Outline several suitable ideas. Go thoroughly through the material and construct a low-fidelity-prototype (paper-prototype) and evaluate. Draw conclusions about the evaluations and suggest desirable changes.

Computer Hardware and Architecture Two tasks are involved:

1. Simulate a computer and use machine instructions to write a few simple programs.
2. Build a small-scaled vehicle, which automatically can follow a coloured tape on the floor. Cross lines had to be counted and the vehicle must stop after having passed a given number of cross lines. It shall also be possible to control the vehicle by remote control.

Compiler Technology Construct a computer language suitable for controlling the robot and its arm. Define it using a meta-language. The compiler do not need to be implemented but discuss its principles.

Numerical Algorithms When the robot arm is going to move something from one place to another there are two problems to be solved:

1. To reach a specified place the angle between the links of the arm must be calculated. This problem leads to a system of non-linear equations and is called the Inverse Kinematic Problem (IKP). The best way to solve these equations is using numerical algorithms.
2. Trajectory planning is necessary to control the path of the arm.

To make the problem simpler the students do not need to deal with the hand, only with the three-linked arm. Implement IKP and a method for trajectory-planning in MATLAB and choose some aspects and examine thoroughly the behaviour of the numerical algorithms. Interpret the results and compare with theory. Illustrate the results in a way that make them plain and easy to understand.

To avoid misunderstandings a contract with FAABFUT would be established. In this contract the students had to specify exactly and concretely which examinations they want to do.

Psychology Students of Psychology should be used as process consultants. They could also be used as experts leading exercises or lectures in some relevant subject, i.e., stress handling and efficiency training.

The members of each team would keep a diary containing weekly notices about events essential for their group process. At the end of the project they would evaluate the progress of their team using an appropriate theory.

Communication The report shall be written in a consistent and professional way. The manuscript shall be examined systematicly and professionally by opponents from another team.

The overall project Make a project plan and a timetable for every sub-project. Decide areas of responsibility for the members of the team. Follow up the plan and the timetable during the project. Evaluate the work at the end.

INDIVIDUAL EXAMINATIONS

Project work are divided among the students, and to guarantee enough knowledge in different subjects we also introduced individual examinations. There was an attempt in Computer Hardware to avoid a written exam. Instead the members of the team should orally explain and discuss their work. Everyone should participate and several alternatives based on theoretical knowledges should be discussed. This was the intention, but it did not work out well. The students were not enough prepared and did not understand the purpose. There was no time to repeat the presentation, thus the students passed without enough knowledge. After one year this attempt was terminated and replaced by a written exam.

We tried to vary the form of the individual examinations in order to get a good view of the students understanding and knowledge. The first year the only grade given was passed, but after this we have given differentiated grades as this was desired by the students.

Human Computer Interaction A paper written at home.

Numerical Algorithms Computer experiments, and a paper written at home and orally presented to the teacher.

Marketing An oral examination.

The remaining subjects Ordinary written examinations.

Half of the credits for the semester are for project work and are examined by groups and half are individual examinations, as listed in the table. The credits are ECTS credits, translated

Table 1: The distribution of ECTS-credits

Subject	Project ECTS	Individual ECTS
Computer Hardware	5.25	2.25
Numerical Algorithms	1.5	3.75
Compiler Technology	1.5	2.25
Human Computer Interaction	2.25	2.25
Marketing	0.75	1.5
Calculation	0.75	1.5
Psychology	1.5	1.5
Communication	1.5	
Total sum	15	15

from Swedish points.

The students of Psychology get 3 ECTS credits for their work as consultants and their tasks were well defined and had a good connection to their future professional work.

The students from LiU School of Management get 7.5 ECTS credits. They had to follow the courses in Psychology and Human Computer Interaction. They would also participate as a members in the project teams and contribute with their knowledge. Their contribution to the team thus was rather weakly formulated.

ORGANISATION OF THE PROJECT WORK

If such a large project is going to function the students must have support. The organisation of the support is illustrated below. The teachers must have opportunity to give the students

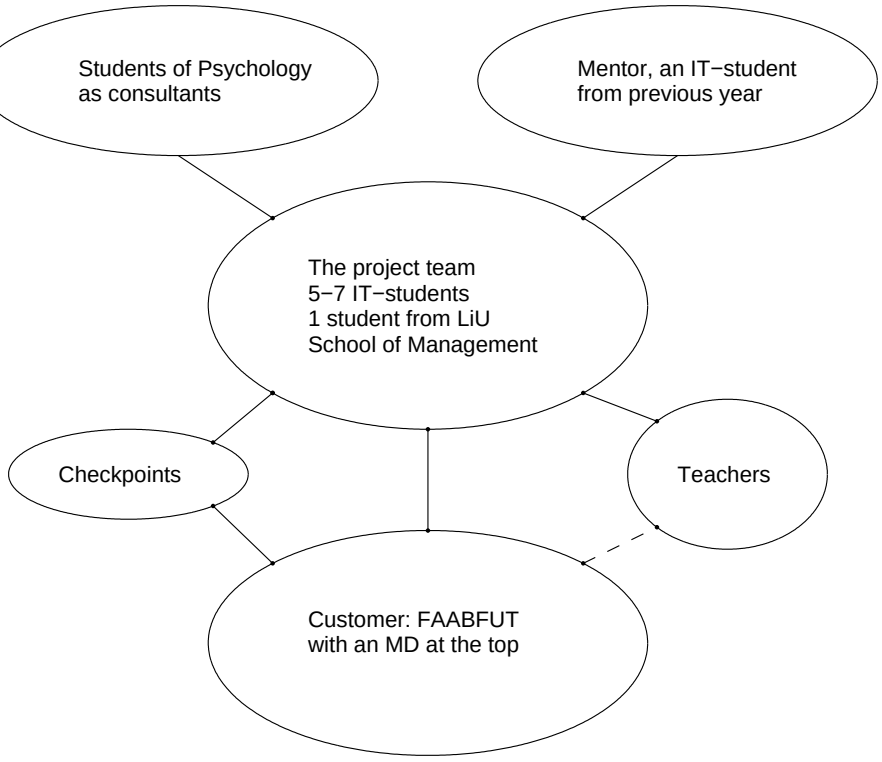

Figure 1: The project team and their support.

feedback several times during the project. For that purpose we arranged five checkpoints[2] during the semester. The checkpoints are used in different ways in different sub-projects. Sometimes the checkpoints are used for formal presentations of a certain part of the project and sometimes they are used for informal discussions.

The first checkpoint occur three weeks from start and then the students have to present their plan for the customers, i.e., FAABFUT. After the presentation the teachers act as teachers, not customers, and meet the members of the teams for discussions and feedback.

At the end of the semester the entire project is presented to FAABFUT. After that the sub-projects are discussed more thoroughly in groups consisting of the teacher and those students who have worked with that sub-project.

[2]This is my translation of what we in Swedish called "avstämningar". It is approximately but not exactly the same as tollgates, used in the project model for CDIO-projects at Linköping University.

The group process and the overall project work were also evaluated at the end of the semester together with the responsible teacher. We wrote down all the instructions both for the project and the individual examinations in an instruction book, which was handed over to the students at start. At the end of August 1997 the first project started.

EVALUATIONS AFTER THE FIRST YEAR

After the first year both the students and the teachers evaluated the project. We got feedback from these evaluations. Some important opinions from the IT-students point of view are listed below. I only include opinions dealing with the project.

- It was very pleasant, interesting and instructive to work in a project.

  We learned a lot, not only about the subjects but also about ourselves. We also learned how to plan our time and to utilise the whole day from 8 a.m. to 5 p.m.

- Both the course in Psychology and the support from the students of Psychology were great experiences. It was very fruitful to learn about the behaviour of groups as PBL is based on team work and now we got a deeper insight in the group process. The students of Psychology were very professional and learned us to notice things we never had thought of before. Furthermore we learned how to criticise in a constructive way.

- It was nice to meet the students from LiU School of Management, but they could not contribute with so many things. Of course they took care of Business Administration which they did quickly and excellently but what else?

- The instruction book was too vague and woolly.

- We would have needed someone who took care of the overall project, and acting as a customer. Someone who is not so much involved in teaching as it is difficult to separate the two roles, teacher and customer. Could not Nahid Shahmehri have done that?

- It would be good to have differentiated grades, e.g., if we will study abroad and compete for attractive places with other students.

Other opinions were:

- The students of Psychology were very satisfied. They got professional training and had learned a lot.

- The students from LiU School of Management on the other hand were not so pleased. They thought it was nice to meet the IT-students but they did not learn anything new. The project in Business Administration was not as advanced as those projects they had done earlier in their own programme. Most of the contents in the course of Psychology they had also learned earlier. Human Computer Interaction was interesting but as they chose not to participate in this sub-project it did not give deeper knowledge.

- The teacher in Computer Hardware wanted to sharpen the requirements as only 2—3 persons had worked with this sub-project in each team, but the others also got a lot of credits and had not gained so much new knowledge.

- Concerning the robot arm, the students had done some good things but the description in the report was hardly understandable as they tried to describe mathematics with words, i.e. without using any formulas. If you know exactly what they had done you could guess but even then it was hard to understand.

In spite of a certain criticism the final opinion was very positive and both teachers and students thought that this way of working was very constructive.

FURTHER DEVELOPMENTS

We started to prepare next years project directly after the first project was finished. It was obvious that we had to discuss some of the problems mentioned above. At the same time I will describe important changes until today.

Differentiated grades Everybody thought that it was easy to differentiate the grades in individual examinations, so that was implemented. For the project work, passed was still the only grade given.

Nowadays differentiated grades have come into question again. But now the students seems to prefer that passed is the only grade.

Computer Hardware We changed the individual examination to a written exam.

The instruction book was revised and got a more distinct structure.

I think the criticism on the instruction book was motivated, because at first there were many unclear points even for us teachers.

Year after year we revised the instructions and gave more and more specifications, but it did not help, we always got the same comments about indistinctness and vagueness. I think that it is impossible to formulate rules that are distinct enough to suit everyone. Nowadays we try to point out that a certain vagueness is a part of the project work, real projects are not quite well specified and it is up to the teams to solve this problem.

The situation for students of Management was not satisfactory and had to be changed in some way, but what was to be done. We really did not want them to work with the Business Administration project. It had been better that the IT-students had done that, as for them it had been new experiences. But of course the students choose the most competent person for the job. We could perhaps give instructions to the students from LiU School of Management not to work with Business Administration. On the other hand we want to keep the freedom for the students to plan their own work. It is also rather difficult to know if they follow the instructions. We tried instead to give the students from LiU School of Management more specific tasks in Human Computer Interaction. These tasks would be related to management and should be interesting for them, we thought. But always there were a lot of misunderstandings so it never worked out well and the dissatisfaction got worse the following years. This had to be solved, or it would be meaningless for them to participate. One of the students of Management suggested that they could be project leaders. Why not, we thought. The IT-students, however, thought it was instructive to be leaders themselves and that it was a bad idea to have a leader who did not know anything about the subjects.

The attempt with students of Management as project leaders started in 2000. At the same time Jörgen Ljung was engaged as MD for FAABFUT and he also was instructor and supervisor for the students of Management. They would also take a leadership course where Jörgen was examiner. Unfortunately this course was not started until the middle of the semester. We naturally gave them instructions at the start but this was not enough, so the start was rather hard for them. It was not easy for them to defend themselves when the IT-students now and then indicated their lack of technical knowledge. But the students of Management became more and more familiar with their task and they got good experiences and learned a lot. We understood that this was the right way to go, but we must give the students a better start. Before the project started we organised one day, when they got the opportunity to meet all the teachers, the mentors for the IT-students and their own mentor, who was one of the project

leaders from last year. We described the project and the subjects involved and we gave them time to ask questions and to discuss their working conditions. We also told them that you can be a good leader even if you lack the technical knowledge.

Nowadays the comments from the IT-students are that it is comfortable to have a leader who is chairman, writes the agenda and checks the overall planning. It is good to have a person as a leader who is not involved in the project work.

A person responsible for the overall project We thought that this was a good idea but it could not be Nahid. She had got a lot of other engagements and had to leave the work with this project. We had to get a person with knowledge in project work and leadership. This person would act as the MD of FAABFUT and take care of the overall project work, both teaching and follow-up. It was however difficult to find a person with this knowledge who had time to work with us. To teach and participate in some checkpoints do not take so much time so we could at last persuade a person to take the job. The problem was that he had a lot of other engagements and did not really have time to be involved in this project too. After one year he left us due to lack of time. The same thing happened the next year, but then we succeeded to engage Jörgen Ljung from the department of Management and Economics. Since 2000 he has been our MD and it has worked out very well. As Jörgen also instructs and supervises the students of LiU School of Management he gets good insight into how the teams perform their project work.

The development of some sub-projects will be described in the next section. I have chosen those sub-projects where evident changes have been implemented.

THE SUB-PROJECTS

Constructing an automatic vehicle

The sub-project in Computer Hardware gets more credit than any other sub-project. As it is a construction project it is essential that everybody gets training in building an electronic product. After some years we required that everybody had to work approximately the same amount of time with the construction of the vehicle. This had to be controlled and therefore the time used by every person had to be reported once a week.

When the CDIO-projects were established in other programmes it became desirable to work in a similar way in this project. Thus a project model was introduced and the students had to formulate the requirement specification themselves. Tollgates with specified requirements are used in order to control the progress and to discover problems in time.

Controlling the robot arm

In this sub-project I have used the checkpoints to help the students to increase the quality of their final report. I took the checkpoints one by one when I had found which problems the students had and realised how to help them to solve the problems.

- At Checkpoint 3 (at the end of September) the students had to write down the equations for the Inverse Kinematic Problem. The equations must be correct and the students had to illustrate and explain them, in order to make the description easy to understand for a person with the same background in mathematics as themselves. I gave them feedback and guided them in the ability of writing mathematics. In this way the quality of the report was increased. They also got the knowledge they needed about the problem.

- At Checkpoint 4 (at the end of October) a contract with FAABFUT was to be established. In the contract the teams should describe which experiment they wanted to do. The problem was that the description often was too vague and general and did not give real information about what they wanted to do. The reason for this was mainly that they did not yet understand the problems.

  After some years I introduced oral presentations of their contracts. At the same time they had to explain what they wanted to do. The members of another team were opponents and they had the task to see if the contract was clear enough. In this way the students were forced to learn more about the problems. A good contract makes it much easier for them to implement computer programs and solve the problems.

- At Checkpoint 5 (at the end of November) I had no special requirements. The students could discuss their problems and their results if they had any. I noticed that if the students had written a report on that occasion, I could give them comments and then the quality of their work increased. Three years ago I decided that every team must hand in a preliminary report a few days before checkpoint 5. Then I could give them feedback and they had possibility to correct their mistakes and to make complements in an early stage. When this was done I could approve their work.

- At the final discussion (at the beginning of January), those who had worked with this sub-project participated. Every team had done different investigations and we could compare the results and the analyses. The students knew that they had done a good job, and then they also were able to discover the advantages of other ideas.

  Earlier there were a lot of errors and unclear points in their reports. I had to point out that and the students got a little disappointed and the lively discussions could vanish.

Ethics

As mentioned before, Compiler Technology was replaced by Ethics in 2003. The first two years there was a written exam exactly as it had been in Compiler Technology.

In the sub-project in Ethics the students had to identify and analyse ethical aspects within the project. They should use ethical theories to motivate their point of view. The teacher in Ethics noticed that the students had difficulties in following a logical line of argumentation. In order to give them more training to discuss and to argue using arguments based on theories, the exam was changed to a short test with basic questions and two seminars, where ethical cases would be discussed. The only grade given was passed. This autumn was the first time with this examination form and the students were very satisfied and they studied the literature more careful than earlier.

It is also desirable to increase the quality of the final report. Therefore the teacher shall approve the report before the final discussion in the same way as I have done. This we are going to implement next autumn.

CONCLUSIONS

There are several advantages with this project.

- First of all, the students from all three programs are very satisfied and they got *training in their respective profession*.
- The teachers also appreciate that the students have possibilities to *apply* their knowledge in the project.
- As it is a large project the students go through many phases. They sometimes are frustrated, irritated, unmotivated and stressed if there are a lot of problems in the project and the work seems to stand still. These negative periods often are followed by positive ones where happiness, motivation and fruitful work dominate.

  The *team process* also becomes important as they are colleagues for almost half a year. Thus they have to have an efficient organisation. They also have to solve conflicts before the situation gets too serious.
- The IT-students *cooperate* with student from other faculties.
- Individual examinations and project work are *included* in the project.
- Many subjects from different departments and different faculties are *integrated*.
- Knowledge from *mathematics* is included in the project.
- The *context* in which the technical system is used is also investigated. These investigations are important parts of the project.
- The project is formulated as a *pre-study*. As a result there is an advanced product for the market and the technical constructions can be done with just enough work.
- As the students are *free to choose* their own business idea and the direction of their work, every project is unique.
- The formulation as *a pre-study* also has the advantage that new technique can be used with very small changes in the instructions.
- Every teacher take care of hers/his own sub-project. This makes the administration easier.

The positive part dominates but of course there are disadvantages which should be mentioned too.

- It is a lot of work to administrate such a large project with so many people involved. As the teachers work in different departments they seldom meet each other spontaneously. Thus every meeting must be organised and that takes time.
- There is extra work for the teachers with checkpoints, documents to read through and students needing support in their project work. But as you get a good contact with the students it is often worth the extra amount of work.
- As in every project, the students only work with a couple of sub-projects and therefore they do not get a very good knowledge about the other subjects. This disadvantage is perhaps more valid in this project since the subjects are quite different.

We did not use the CDIO Standards [1] when our project was developed. It can therefore be interesting to compare and see if some of the CDIO Standards are applicable in our project.

CDIO as Context Most of the instructions in the *Conceive* stage are included in our project, as for example defining costumers needs, market analysis, profitability calculations and ethical considerations.

Even a lot of the *Design* stage is relevant in our project, particularly in the sub-projects of Computer Hardware and Human Computer Interaction. In the sub-project concerning Numerical Algorithms, we never leave the *Conceive* stage as the task is to do examinations in order to understand how the algorithms work.

If you look at the real product nothing is *Implemented*. The automatic vehicle is only a prototype used to investigate the technique. But that depends on the definition. If you define the pre-study as the final product ordered by FAABFUT, then every sub-project includes the *Implement* stage.

We do not really reach the *Operate* stage, but the teams have visions about the environment where the robot is going to operate and the computer system is going to be used.

Our project can also be regarded as a *Design-Build Experience*.

CDIO Syllabus Outcomes Many of the learning outcomes in the CDIO Syllabus are similar to our syllabus, for example engineering reasoning and problem solving, experimentation and knowledge discovery, critical thinking, professional ethics, teamwork, leadership and communication. But we have not used the CDIO Syllabus to codify the learning outcomes.

Integrated Curriculum This is exactly what we do,

Active Learning and Integrated Learning Experiences are guiding principles in PBL and permeates the IT-programme including the project. We also use different forms of examination to match the learning outcomes.

The conclusion is that we have implemented a lot of the CDIO Standards in spite of the fact that CDIO was unknown for us when our project started.

In our project the context where the product is going to be used is very important. Teachers from non-technical subjects are involved and the sub-projects in these areas are as important as the technical ones. On the other hand we do not emphasise the engineering skills as much as I have understood that CDIO-projects do.

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