Integration of psychology, economy and information technology

Patrick Lambrix
Department of Computer and Information Science
Linköpings universitet
S-581 83, Linköping, Sweden
patla@ida.liu.se

Sammanfattning

En ingenjör eller civilingenjör verkar idag ofta i samarbete med människor från helt andra kunskapsområden. För att nå bra resultat är det därför väsentligt att förstå tillräckligt mycket om det område där tekniken används. Mot bakgrund av detta har en termin utvecklats vid Linköpings universitet där studenter från civilingenjörsprogrammet för informationsteknologi läser tillsammans med studenter från psykolog- och ekonomutbildningarna. I grupper grundar teknolog- och ekonomstudenterna tillsammans företag som genomför ett givet projekt. Psykologstudenterna fungerar som konsulter till företagen. I projektet ingår att utveckla och bygga en prototyp för en rörlig robot, att genomföra en analys av beräkningstekniska problem vid styrning och kontroll av en robotarms rörelser och att utveckla i mjukvara ett lagerhanteringssystem. Därutöver skall en ekonomisk analys av systemet och en analys av potentiella kunder genomföras. Ämnen från sex olika institutioner är integrerade i projektet. Studenterna samläser delvis, även om de har olika inlärningsmål. Samarbetet i projektet leder till en överföring av information och kunskap mellan studentgrupperna. Erfarenheterna pekar på att studenterna får en större motivation och en integrerad syn på teknik och andra ämnen tack vare det integrerade projektet. Studieformen främjar också samarbete och förståelse mellan olika yrkeskulturer.

Abstract

Engineers often work together with professionals from entirely different areas. Therefore, it is important for the engineers to understand enough of these other areas where technology is used, to obtain good results. To this aim a term has been developed within the civil engineering curriculum in information technology at Linköpings universitet, where the students work and study together with students from the psychology and economics education programs. The information technology and economics students build companies together and perform a project. The psychology students act as consultants for the different companies. The project includes the design and building of a mobile robot, an analysis of the necessary calculations for the control of a robot arm, the development and implementation of a prototype of a stock administration program, as well as an economic analysis of the system and a market analysis with respect to their product. Subjects from six departments are integrated in the project. The students work and study together for different parts of the project, although the learning goals differ between the different programs. The cooperation in the project leads to a transfer of information and knowledge between the students. Experience also suggests that the students obtain a better motivation and an integrated view of technology and the other areas as a result of the integrated project. The learning method also promotes cooperation and understanding between different professional cultures.

1 Introduction

Engineers often work together with professionals from entirely different areas. Therefore, it is important for the engineers to understand enough of these other areas where technology is used, to obtain good results. To this aim a term has been developed within the civil engineering curriculum in information technology at Linköpings universitet,[1] where the students work and study together with students from the psychology and economics education programs.

[1]The term described in this paper is the fifth term in the curriculum. For a discussion about the pedagogical ideas behind the information technology curriculum see [1, 2]. The third term of this curriculum is described in [3].

This paper is structured as follows. In section 2 we describe how the information in this paper was gathered and from which sources. Section 3 describes the goals of the fifth term in the civil engineering curriculum in information technology while the organization of the term is described in section 4 and the examination forms in section 5. In section 6 we describe how the term was evaluated by the teachers and the students. Our own observations are described in section 7. We discuss the expectations, observations regarding the teachers, the resources, the way the students organized themselves in groups, the cooperation between the students from different educational programs and some general observations. At the time of writing, the term is running for the second time. In section 8 we describe the changes that were made to the term after the evaluation of the first time and briefly state some of the observed effects. The paper concludes in section 9.

2 Method

The information that is described in this report was gathered during different phases: the preparation phase including course development and the division of students in groups, the actual term including the project work and the work on different subjects, and the evaluation and further development phase. We gathered the information in a number of ways.

- We were observers in different kinds of meeting. We observed and took notes, but played no active role in the discussions. The meetings we observed were:
  - Development meetings. In these meetings teachers developed the term.
  - Group division meeting. A number of teachers divided the students into project groups.
  - Student project meetings. The students worked on and discussed their projects.
  - Psychology oral exam. This exam was a round table discussion on the project groups' organization and cooperation.

  - Final presentation of the results of the project groups.
  - Evaluation meetings. Students and teachers met together to evaluate the term.
  - Evaluation and development meetings. The teachers discussed and evaluated the term and started with the further development for the following year.

- We did enquiries using questionnaires for students as well as teachers.
- We studied a number of texts.
  - Documentation folder. This contains the documents that the students receive at the beginning of the term.
  - Transcripts of student evaluation meetings.
  - Final reports from project groups.

3 Goals

The overall learning goals for the students during the term can be divided in two kinds of learning goals. The first kind is related to project work, while the other kind of learning goals is mainly related to actual subjects.

With respect to the project-related learning goals the students learn to:

- work within a project and obtain insight in different models for project management,
- practise project planning and follow-up,
- cooperate with project group members, clients and experts from other professions. The cooperation between students from the information technology, psychology and economy programs allows for insight in other professions' work conditions and for obtaining an understanding for technical, economical and behavioral science organization cultures and work methodology.

- to obtain basic knowledge from relevant areas such as computer hardware and architecture, economy, compiler construction, human-computer interaction, numerical algorithms and psychology in parallel with project work. (This learning goal is mainly for the students from the information technology program and to a smaller degree for the students from the economy program.)

With respect to the different subjects the students from the different education programs have different learning goals. For the students from the information technology program the term gives 20 credit points.[2] The subjects that they study are:

- computer hardware and architecture. This is taught by the department of electrical engineering. The learning goals are to learn how a computer can be constructed, as well as learning about different types of computer models and principles for input and output. Further, the students learn how to use a computer as a control unit for a simple robot.

- compiler construction. This is taught by the department of computer and information science. The students learn about the implementation of programming languages including such items as compilation, parsing, code generation and memory management.

- business economics. This is taught by the department of economics. The students learn how to do a simple calculation of development, investment, capital and production costs. They also learn to do profitability calculations, perform a market analysis and analyze clients' needs.

- human-computer interaction. This is taught by the department of computer and information science. In this area the students obtain certain skills and a critical attitude in the area of user-oriented system development. In particular, they look at design, prototyping and evaluation.

- numerical algorithms. This is taught by the department of mathematics. The students obtain basic knowledge in numerical methods and

[2]One credit point is given for one week full-time study.

their use in solving practical numerical problems. They also learn to use numerical software and make judgements about the reasonability of the results. Further, they gain insight in computer arithmetic and how standard functions can be implemented in an efficient way.

- psychology. This is taught by the department of education and psychology. The students obtain basic knowledge on theories about the structure of and processes in small working groups. They learn to make use of external social-psychological experts as support for the work group.

- communication. This is taught by the themes institute for technology and social change. In this term the students mainly learn to write and critique texts.

For the economy students, this course gives 5 points and is taken in parallel with other courses in the curriculum. The subjects that they study are:

- introduction to computer science. This is taught by the department of computer and information science. The students receive an orientation in basic notions related to hardware, software, programming, networks and programming languages.

- psychology. This is taught by the department of education and psychology. The students obtain basic knowledge on theories about the structure of and processes in small working groups. They learn to participate in a multi-disciplinary working group and communicate with technical and social-psychological experts.

- human-computer interaction. This is taught by the department of computer and information science. The students obtain knowledge about usability and different views on usability as well as techniques and methods for the development of usable systems.

- business economics. This is taught by the department of economics. The students learn to work on problems related to business-oriented systems. They learn about the connections between different systems for strategic, tactical and operational decisions.

For the psychology students the participation in the term is part of their studies on society, organization and group psychology. They learn to write contracts with organizations and work as consultants.

4 Organization

The term is organized as a project. However, differently to most project courses, in addition to the knowledge in different subject areas that is needed for the project, the students also have learning goals in these areas that are not directly related to the project.

The scenario of the project is the following. A company, LinkIT, wants to investigate the possibility of using its knowledge and production capacity for new products. LinkIT has formulated a number of pre-studies where potential products need to be investigated in terms of technology and market. LinkIT has decided to let a number of different companies do similar pre-studies. One of the ideas that LinkIT wants to see investigated is the possibility of storage systems, including the stock administration and robot systems that perform the actual storage.

LinkIT is represented by a president and divisions. The president is a teacher who has no responsibility within the subjects of the term. The divisions are system design, economy, computation, computer hardware and compilers. The division heads are the teachers responsible for the associated subjects within the term.

The order of LinkIT consists of the following parts:

- a commercial evaluation including a marketing study with marketing plan and a profitability assessment,
- an analysis and design of a stock administration system and implementation of an interactive prototype,
- an investigation on which technology should be used for the construction of a mobile robot, the implementation of a prototype and a complexity study of the control unit,

- an analysis of the necessary calculations for the control of a robot arm and
- a study of control languages and implementation of a prototype.

The students are divided into small companies that each do a pre-study for LinkIT. The companies contain between five and seven students[3] from the information technology program and one or two students from the economy program. In total there are four companies. The psychology students are contracted by the companies as external consultants on group psychology. The contract that the student companies and the psychology consultants decide on, stipulates in what form the consultants will work for the company.

The first day of the term starts with a kick-off meeting with all students, teachers and other people involved in the project. The students get to know the people involved and receive information about the term including information about the learning goals, the project, the different subjects and the group (student company) they belong to. They also receive the documentation folder that contains general information, a schedule for the lectures, information about the project work and information about the different subjects. The project information includes a problem description, a description of the different parts in the LinkIT order and details on prototypes, reports and demonstrations with deadlines. The information about the subjects includes the learning goals and details about examination, available resources and literature lists. After the kick-off meeting the different student companies meet and the psychology students visit the companies and explain their part in the term in some more detail. In the afternoon of the first day there is a lecture on project planning and the student companies are assigned a mentor. The mentor helps the students during the term with the organization of the project group and the project work.

The first two weeks are rather intensive with many scheduled project meetings and lectures. For each of the subjects introductory lectures are given to familiarize the students with the relevant subjects. Further, a study visit to a company that specializes in industrial robots, is scheduled. There are also question sessions where the teachers are available to answer questions that

[3]Five during the first year and six or seven during the second year.

emerged during the planning of the project. After the first two weeks the student companies have to present a planning report.

For the rest of the term the students work in parallel on the project and on the different subjects. With respect to the subjects a number of lectures, exercise sessions and labs are scheduled. For computer hardware and architecture there are 14 hours of lectures. These lectures are in common with other civil engineering students. The compiler construction subject provides 12 hours of lectures and 16 hours of exercise sessions. The highest amount of scheduled activity is for numerical analysis: 22 hours of lectures, 10 hour of exercise sessions and 10 hours of labs. The other subjects have only lectures: business economics (10 hours), human-computer interaction (8 hours), psychology (14 hours) and communication (2 hours). Some of these hours should be planned by the students and ordered from the teachers. Most of the subjects have a similar content as courses in other education programs. However, most teachers reported that they had changed their teaching to connect the lectures, exercises and labs closer to the project work. The labs and exercises had a more open nature that left more room for the students' ideas and creativity than in similar courses in other programs. The teachers who did not report to adopt a different teaching style in this term, already taught in project-oriented courses with similar content in other education programs or had only very few lectures at their disposal.

With respect to the project work there are a number of partial report meetings with the representatives of the divisions within LinkIT. During these meetings the status and progress of the project work is discussed. These meetings are seen as support to the ongoing work as well as a way to receive feedback on the work that has been done so far.

5 Examination

An important question for the developers of the term was how to evaluate whether the learning goals were achieved. It was decided to divide the evaluation of the subjects and the project work. Most of the evaluation in the project work is done in group, while most of the work in the subjects is evaluated individually.

5.1 Subjects

With respect to the evaluation in the subjects there are written exams for psychology, compiler construction and business economics. There are oral exams in business economics and numerical algorithms. Further, for the subject of human-computer interaction the evaluation takes the form of essay writing.

5.2 Project

As seen above, with respect to the project there are a number of partial report meetings, some of which have an examination character while others are mainly to follow up the progression of the project work.

A first evaluation is done after two weeks when the students hand in their project plan and present the main issues in the project plan in a oral presentation. After the presentation there is a follow-up meeting with each of the teachers representing divisions within LinkIT.

Further, there are a number of prototype presentations and demonstrations. The students present their solutions and demonstrate their prototypes. The teachers ask questions about the solutions, alternative solutions and motivations for the choices the students made in their solutions. A first prototype demonstration involves the building of a computer supporting a given machine language. A second prototype demonstration involves the building of a robot that can follow a path marked on the floor.

The psychology examination related to the project work has the form of a discussion seminar. For each of the student companies the group's view on the cooperation within the group is presented. The issues they discuss include the group structure and the division of the project work among the group members, the role of the psychology students for the group, the different phases the group went through, the communication within the group, the communication between the students from the different education programs and the differences between the different professional cultures. The psychology students comment on the observations of the student companies and present their own observations. The students belonging to the other compa-

nies ask questions and try to relate the observations to their own experiences within their own company.

The final examination for the project work consists of a final report and a presentation as well as an opposition to the project work of another company. The final report consists of two parts. The first part is a description of the project work as requested by LinkIT. The contents of the report consist of an introduction, a description of each part of the LinkIT order and a conclusion. The second part is an internal document describing an evaluation of the project work and process. Each student company receives the final report of one other company and is required to review the report. Finally, a seminar is held where each student company presents its work in general and the opposing companies present their reviews. After the general presentation the companies also present their solutions for the different parts in the LinkIT order in more detail for the different division heads.

6 Evaluation and Follow-up

The teachers evaluated the progress of the term in evaluation meetings which were held during the term. The teachers and student representatives met also after half of the term had passed to discuss the progress. Further, the students had their own evaluation meeting close to the end of the term. The term was concluded with a final evaluation meeting where the different companies, students from the different education programs and teachers gave their view of the term.

7 Observations

In this section we describe our observations. We have divided the observations into several parts. In the expectations section we describe the expectations that the students and the teachers had at the beginning of the term and compare this with respect to their experience. In the teacher section we describe the background of the teachers and their cooperation. In the resources section we describe the observations with respect to the different

resources such as study visits and mentors. The project groups were organized in different ways. This we describe next. Further, we describe the cooperation between the students of different education programs. In the last section we describe more general observations.

7.1 Expectations

Many students reported that they had high expectations for this term. The idea that they could cooperate with students from other educational programs within a project seemed very interesting. Also, this had not been tried before at our university in such a large scale. On the other hand, many students also felt that there was a fuzzyness with respect to the term, mostly because they felt they had no idea what to expect from the term in more detail. For instance, some students did not expect that there would be learning goals for the different subjects in addition to what was needed from these subjects for the project. Also, some students had expected that the teachers would steer the project work in a much larger degree than what was actually done. However, afterwards, it turned out that most students thought this had been the most exciting term in their curriculum.

The economy teachers expected that the project term would be an ideal way to reach the learning goals with respect to economy. With respect to psychology, it would be the first time that students gain practical experience in consulting.

In general, the teachers were very positive towards their cooperation in the term. They expected it to be exciting to work with teachers from other departments and within a form that had not been used before. The main difficulties that were expected were the integration of the different areas within one project as well as the organization of the cooperation between the students from the different programs. It was felt that the term should not consist of different courses in parallel, but that a real integration should be made within the project. On the other hand, it was also felt that the different subjects could not only concentrate on the parts that were needed for the project. The solution that was proposed afterwards, was to integrate the subjects within the project, but to have also learning goals outside of the

project. The integration of the different education programs with different learning goals, emerged naturally from discussions among the teachers (see below).

7.2 Teachers

The teachers were recruited from six departments based on expertise and interest to work in an integrated term. Most teachers had worked in projects before. Most teachers had cooperated with teachers at other departments before.

The development work was done in many meetings with many discussions going from "philosophical" discussions on what a project is or what the criteria for proofs are in the different disciplines to discussions on very practical issues such as the scheduling of the lectures in the term. It was generally felt among the teachers that much more discussions were needed in the development of multi-disciplinary courses such as this term than for other courses. The teachers also felt that it was through these discussions that the form of the project term slowly emerged.

The terminology that is used in the different areas was a threshold at the start of the development and every now and then discussions were needed to explain terminology or to come to an agreement on a working definition for a particular concept. However, the terminology issue was not felt to be a major obstacle. Neither was the unfamiliarity with other areas than one's own a major obstacle. None of the teachers reported the need to read books in another area to help their understanding of the area, although some teachers did report that they had extra discussions with teachers from other areas. Although their knowledge of the other areas may not have been deep knowledge, it was felt to be sufficient for the cooperation in this term. One teacher also reported that she started reading books from another area out of interest and a newly found connection between her own area and the other area.

Although there was a difference between the culture and in particular the working and meeting styles of the different departments, most teachers reported that they had not changed their own working style or only very little.

At the same time they thought that the other teachers had changed their working style to some degree to come closer to their own working style.

7.3 Resources

The kick-off meeting was appreciated by the students and the teachers. It provided an opportunity to get an overview of the whole term in the beginning. Also the introductory lectures during the first two weeks helped the students much to grasp the work involved in the term.

The study visit at the company specialized in robots was considered to be successful by the students and the teachers. It gave the students a good overview of the project. The company presented its work in a number of presentations and a tour of the work place. The study visit showed the students real-life applications of parts of their project work and provided ideas that could be used during the project. The students also contacted other companies and visited them on their own initiative.

The students found it difficult to plan lectures and order lectures from the teachers. They found it hard to decide on what topics they wanted to have lectures on and when.

The scheduled group meetings were intended to be used as project meetings as well as meetings where the students could discuss the subjects. As most of the students had experience in problem-based learning, there was an expectation that the students would use some of the meetings as base group meetings.[4] However, it turned out that the meetings were almost only used as project meetings. Each student was responsible for his own reaching of the learning goals for the subjects and the subjects were not discussed much in group.

[4]The learning philosophy behind the information technology curriculum is problem-based learning. In this curriculum a base group consists typically of six to eight persons. The base groups usually meet twice a week together with a tutor. The tutor is mainly concerned with the group dynamics. During the base group meetings the students discuss different given situations within a larger scenario. The goal of the meetings is to define individual learning goals for each of the group members based on the situations, the overall learning goals and the students' backgrounds.

The fact that the project mentors were not responsible for any of the subjects and therefore could be regarded as independent, was considered to be positive. The mentors were used mostly to help with the organization of the student companies and with the planning of the project work. Some groups used the mentor every now and then also as a base group tutor.[5] The mentors spent different amounts of time and effort for the different groups. Therefore, some groups used the mentor a great deal and received in this way a large support in the planning phase of the project, while other groups decided that they did not need a mentor that much.

In addition to discussing the status and progress of the project work the partial report meetings were used much as an opportunity to ask questions. The questions aimed at feedback on the work that had been done so far as well as explanation of issues within the subject area and further work.

In general, the examination of the project and the subjects was perceived as positive. In particular, the project presentations and demonstrations were interesting for both students and teachers. In addition to being an examination these sessions were also learning occasions. The individual subject examinations were not so different from what the students were used to. These exams were spread over the term and could therefore interfere with the project work. The students needed to take this into account during their planning.

7.4 Project group organization

The student companies used different company organizations. One group had a flat organization, where everybody was responsible for the whole project work. The aim of the group was that everybody would learn as much as possible of every part of the project. Afterwards, it was felt that this was too ambitious. The solution was that the ambition for the actual project work was lowered.

One group decided to have one project leader and a number of task leaders. They had people responsible for documentation, quality, testing, client

[5] See previous footnote.

contact etc. A problem, however, was that different tasks needed to be performed at different periods in time during the term. Therefore, it was not easy to schedule the work in a way that all students could divide their time in an optimal way during the term. Also, it was realized that the tasks required too different amounts of time. The student company that used this model decided to change into the model described below.

Another model that was used by most groups was to have one project leader and a number of division leaders. The divisions were similar to the divisions in LinkIT. This model seemed to work best for the students. It was possible to divide the project work into "fair" amounts of work among the students, not all students needed to know everything about every subject and the project work was quite ambitious. Two negative points were the following. It was felt that some division leaders became too strongly linked to their division in the sense that they would see more to the division needs than to the project needs. Also it was felt by the division leaders that they seemed not to have enough time for the topics of the other divisions.[6]

In two of the groups interesting conflicts arose. The first conflict was in a group where part of the project group wanted to follow one organizational model while the other part of the group wanted to follow another organizational model. This conflict was not really solved. Both parts of the group followed their own model as a sub-group and the results of the sub-groups were combined in the larger group. The second conflict occurred in one group where there was only one female student. She found that her ideas were not given as much space as the ideas of the other members of the group. After the male students immediately and unanimously decided that that was not the case, they realized that it might be true after all. They then started paying more attention to the ideas of the female student.

7.5 Student cooperation

The cooperation between students from the information technology and economy programs was difficult in the beginning. The main reasons that were

[6] During the second time the course is run, the organization within the different projects groups is similar to this last model.

reported were the following. First, the students from the same education program already knew each other well. Within a student company there were between five and seven students from the information technology program and one or two students from the economy program. It took some time before the students from different education programs got to know each other. Therefore, most groups decided to organize some common extra-curricular activities.

An interesting cultural difference was the use of communication tools. The information technology students were used to do almost all their communication via electronic mail. They all checked their mailbox at least once a day. This, however, was not the case for the economy students and even less so for the psychology students. They were used to call each other by telephone and did not use electronic mail that often. Therefore, in the beginning some information did not reach the target person in time.

Another reason for the difficult start was the terminology problem. Often, terms from the other culture were not understood or used in a different way. This problem was diminished, however, through the overview lectures in the beginning of the term as well as through "mini-lectures" that were given by the students within a student company to their colleagues from another education program.

The last main problem was related to the educational background. As the teaching philosophy of the information technology program is based on problem-based learning, these students had experience with learning modules where different subjects were integrated into a whole. These students had also experience in working in projects. The economy students lacked this experience.

The students reported that after the difficult beginning the cooperation between the information technology and economy students worked smoothly, although the level of cooperation could vary from one student company to another. In one of the groups the cooperation between the students from the information technology and economy programs became quite close. It was the choice of the group to work closely in order to learn as much as possible of each other's area. In another group the different divisions within the student company did mainly their own work in groups of two and therefore as well

the economy students. In yet another group all the students had meetings together in the beginning, but later on the information technology students had many technical meetings without the economy students. In this case the information technology students met daily, but they did not meet the economy students that often. This had as result that sometimes decisions made in the technical meetings were not made available to the economy students. In the two latter groups the "we-them" feeling was the strongest. Interestingly, this was also reflected in the way the students were seated around the meeting table.

The information technology students reported that through the cooperation with the economy students they had learned to appreciate the non-technical aspects in a project. Similarly, the economy students reported that they had learned not to see projects only in terms of loss and profit.

The psychology students built their own company. The employees of the company worked as consultants for the student companies. All students expressed their satisfaction about the interaction between the student companies and the psychology consultants. The role of the consultants differed, however, between the student companies. In some groups the psychology students acted as observers that did not take an active role in the meetings. After the meetings they would discuss their observations with the group and give advice on how to improve the working of the group. In other groups the psychology students took an active part as a catalyst that steered the group dynamics of the group, much as the base group supervisors in problem-based learning. The student companies reported that they often followed the advice from the psychology students, but not always.

7.6 General

In general, the term was considered to be a success by students and teachers. The students thought it was exciting to work with students from other programs in a project. Also the fact that many different areas were integrated and that they could work in a way similar to how it is done in industry projects, was considered positive.

There are different levels of integration of the different areas in the project

possible. The areas can be different parts of the same project or they can be integrated parts of the project. In this term the project was divided in a number of parts that each relied on different areas. The strongest integration occurred between economy and human-computer interaction.

An observation that was made by students as well as teachers was that the project work and the subjects need clear boundaries. This has led to an update of the documentation of the learning goals for project and the subjects. The fact that there are also learning goals for the subjects that are not part of the project work, is an important difference between this term and other project courses. This means that there is a potential conflict between the division of the projects into sub-problems that are solved by individual members of the groups and the fact that knowledge needed to solve these sub-problems belongs to the learning goals for every member in the group.

As is normal for a course that runs for the first year, there were some practical problems. The hardest practical problem was the scheduling of the term. As the information technology program worked full-time on the project term, their schedule was quite flexible. The students from the other education programs, however, only worked part-time on the project term and therefore needed to take into account other courses as well. Further, there seemed to be a difference in flexibility with respect to scheduling within different faculties.

8 Changes

In this section we describe the main changes that were made to the term as a result of the different evaluations of the term. As the term is running for the second time at the time of writing, we only briefly state the effects the changes had. These effects have been observed by the responsible of the term, but no careful evaluation has been made yet.

A number of documents were improved. The main document in the documentation folder that the students received at the start of the term, was largely rewritten. A main difference between the old and the new version is the fact that in the new version a clear distinction is made between project

goals and subject goals. This helped clarify a number of questions that occurred during the first year. Further, the specification documents for the robot have been improved with clearer instructions on the requirements.

A number of roles within the term were defined more clearly (e.g. the role of the director of LinkIT) and a number of administrative routines were improved.

The students were not required anymore to plan lectures within the schedule. The lectures were already scheduled from the start of the term.

A written exam for computer hardware and architecture was added. This allowed for a better way to check whether the individual learning goals were satisfied.

An extra study visit was scheduled to a company specialized in stock management. The students still plan on their own initiative study visits to other companies where they do a market analysis.

The part of the project dealing with the construction of a mobile robot was reformulated in such a way that it was easier to divide the project into different parts. This allowed for more students to be involved in the actual building of the robot.

The partial report meetings with representatives of the divisions in LinkIT were more strictly scheduled and with clearer goals. It is felt that this change has made the meetings more useful. The students are better prepared and have a better grasp of the problems in the different areas. In total one partial report meeting with the division of computer hardware, one with the division of compilers, two meetings with the division of economics, four with the division of system design and four with the division of computation were scheduled. As a preparation for the meetings the students were required to perform a number of tasks. For instance, for the first meeting with the system design department a project plan was to be handed in. During the second meeting the students had to present an external analysis for the stock administration system. This included a discussion about the target group for the system, an analysis of the work environment where the system will be used as well as a general description of the system's services. During the third meeting a design proposal was presented. During the last partial report

meeting an evaluation plan for the system was discussed.

9 Conclusion

In this paper we have reported about a term where psychology, economy and information technology were integrated. Topics from the different areas were integrated. Students from different education programs participated as well as teachers from different departments. The term was considered to be successful by students as well as teachers. The students obtained a better motivation and an integrated view of technology and the other topics as a result of the integrated project. The learning method also promotes cooperation and understanding between different professional cultures.

Acknowledgements

The main responsible for the term is Ulla Ouchterlony (department of mathematics). Also the following persons have contributed to the term: Magnus Ahlström and Peter Jederström (department of economics), Lauritz Brännström and Stefan Jern (department of education and psychology), Martin Howard, Christian Krysander, Nahid Shahmehri and Jonas Wallgren (department of computer and information science), Magnus Merkel, Karin Mårdsjö and Jörgen Nissen (themes institute for technology and social change), Tomas Svensson (department of electrical engineering), Ingegerd Ånöstam (Library) and Esa Falkenroth, Gunilla Ivefors, Rita Kovordanyi, Eva Ragnemalm, Martin Sköld and Lars Strömberg (department of computer and information science). We also thank the students who have participated in the evaluation meetings and answered the questionnaires.

References

[1] Barrows, H.S., *The Tutorial Process*, Southern Illinois University, School of Medicine, 1988.

[2] Ingemarsson, I., *Problembaserad inlärning i teknisk utbildning*, Kvalitetsarbete vid Linköpings universitet, 1995.

[3] Lambrix, P., Kamkar, M., 'Computer Science as an Integrated Part of Engineering Education', *Proceedings of the Third ACM SIGCSE/SIGCUE Conference on Integrating Technology into Computer Science Education*, pp 153-156, Dublin, Ireland, 1998.