EXPLORING ADVANCED PROJECTS AS MEETING-POINTS BETWEEN STUDENTS AND INDUSTRY

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ABSTRACT

This study includes survey of the Swedish companies and other potential employers perspective/view on the computer science students´ projects as well as the opportunities and limitations for the students. This is the first major study we have undertaken within this bachelor programme to, in depth, investigate both the company and the student views of how we should incorporate industry-oriented working methods in the context of CDIO. From the companies´ perspective, for example we are evaluating questions related to the projects´ size and projects´ output; the confidentiality of the projects; the communication aspects, like how early and how often a company need to meet the students; the job opportunities after graduation; or if the company is interested in other ways of being involved in the bachelor program. Two courses in the last semester, in the Bachelor Programme in Computer Science and Engineering, are implemented as work-based projects. Here, the students have an opportunity to work with an advanced project incorporating both prototype building, software development and academic research. The full time twenty-week project is incorporating the Conceive, Design and Implement parts of the CDIO concept. For the last three years, the proportion of work-based projects have varied between 40 % and 80 % and has mainly been done in co-operation with private companies. A few projects have been done in co-operation with none-profit organizations. The students' perspective is very important and is therefore included in this study. The students from the bachelor programme as well as alumni have participated in the survey. The student survey focuses on expectations, experiences, and reflections from the interaction with the companies. The survey also includes questions related to acquired skills and abilities, limitations and difficulties, as well as job opportunities after the graduation.

KEYWORDS

Advanced projects, IT-Industry, Computer Science and Engineering, CDIO Standards: 2-3, 5-8

INTRODUCTION

Higher engineering education in Sweden contribute not only to educate students with a scientific basis, but also with a high degree of employability for them. According to Swedish Higher Education Authority, a majority students who graduated in the 2017/18 academic year were established in the labor market 1–1.5 years after graduation. The highest establishment had graduates from nursing educations and engineering educations (UKÄ, 2021).

There are at least two reasons behind this high employability, namely the labor market that needs engineers and good education adapted to it. An online documentation review shows that all engineering programmes in Sweden offer education in close relation to the industry

through various activities such as study visits, guest lecturers, as well as different kind of projects and degree theses often with companies as customers. Of course, the cooperation between academia and industry is nothing new and has been discussed not only in Sweden. The questions here are: What expectations have the students and the companies? How to prepare the new generation of students to meet the companies´ s requirements? How to meet the academic requirements?

Different methods have been implemented by the academia. One example we find e.g., in (Einarson & Lundblad, 2014), where the integration is carried out within the frames of a Software Engineering course of 15 credits, and where a small number of the 3rd year volunteer students from two universities (HKR and Lund University, Sweden) have participated in projects with low demands on participation from the companies. The project, called DEMOLA, is mentioned as a bridge to inherent a gap between the industry and academia. The authors evaluate the project according to the CDIO standards 1, 2, 5, 6, 7 and 8.

At Turku University, Finland, a student-centric learning environment called “the FIRMA” that works like a company has been implemented (Säisä, Määttä, & Roslöf, 2017). The model is based on project-based learning. The ICT-students are not only practicing different roles like CEO, project manager, service providers, helpdesk but even develop the projects to internal and external customers. The authors write that the students gain competences relevant for the work-life requirements as well as improve the CDIO skills like teamwork, communication, leadership, analytical reasoning, and problem solving.

At Mongolian University of Science and Technology, the authors (Batdorj, Purevsuren, Purevdorj, & Gonchigsumlaa, 2018) present their experiences on teaching and learning activities as well as the assessment results of four project courses taught during the 3 years period. Even here, the program is based on CDIO syllabus, and the Degree project is the last ‘project in this progression line.

Working as an engineer in Computer Science incorporates a vast variety of different types of work, where the CDIO framework is an excellent guideline to follow. The Bachelor Programme in Computer Science and Engineering, specialization in the Internet of Things at Kristianstad University (HKR, home university of the authors of this paper) in Sweden offers a broad education with a wide horizon of future employment. Most of our engineering students may work as software engineers or mixed software/hardware engineers after their studies. Following CDIO principles since 2014, we prepare students for the future through work-based education and design-build-test by the projects integrated in the courses. After more than 7 years´ experience, we wanted to evaluate the work-based projects as a meeting-points between students and industry.

This article contributes with the structure of the engineering program, including a brief description of the courses of project work, a survey based on the questionnaires sent to industry, students, and alumni, as well as an evaluation of the program.

BACKGROUND

The Bachelor Programme in Computer Science and Engineering, specialization in the Internet of Things at Kristianstad University, is a three-year programme and is provided for both national (Swedish) and international students. The program has existed since 2009 and has undergone three major changes in recent years. In 2013, the programme underwent an

extensive restructuring that led to a clearer focus on Embedded Systems. In 2017, further changes were made to the program, with a clear progression between the courses as well as a progression in academic skills. Further improvement of the programme was adopting constructive linking (Biggs & Tang, 2011). Constructive linking is based on the idea that the course's teaching and learning activities as well as its examination and assessment methods should be linked to the course's learning objectives.

As seen in Figure 1, the programme structure is built up by progression chains within and between four subject groupings. The focus has been changed to Internet of Things (IoT). New courses were introduced to strengthen progressions in mathematics and physics (see Figure 1, the blue track), programming (the yellow track), computer science (the violet track) and computer engineering with the main specialization in IoT (the green track).

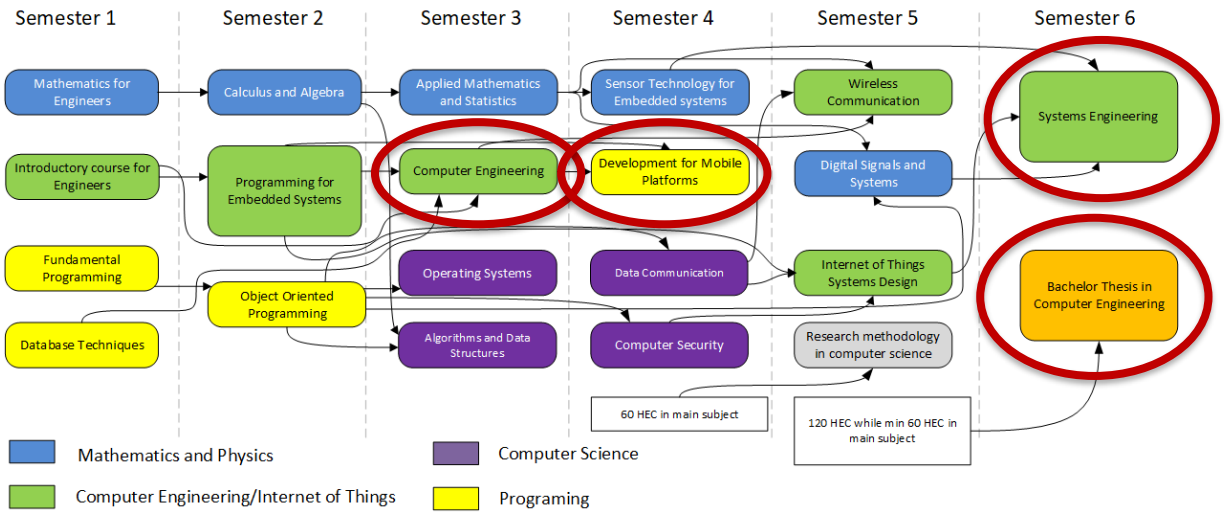

Figure 1: Bachelor Program in Computer Science and Engineering, HKR, (TBIT2, 2020). The courses including the project work are enclosed by red circles.

The students, as future engineers must be trained to work in projects, especially in close relation to the companies. The courses including the project work are enclosed by red circles in Figure 1. Two introductory project courses, Computer Engineering and Development for Mobile platform are given during the second year of the study programme. In both these courses the students are introduced in agile project management. Systems Engineering and Bachelor Thesis in Computer Engineering contain advanced projects and are given during the last term of the study. These two courses in the last semester are incorporating a large part of the different subjects and are the last step in the constructive linking in the programme.

In the last revision, that was introduced in 2020, a new course has been added, "Research methodology in computer science" to ensure research connection and raise students' scientific attitudes as well as prepare students for the Bachelor Thesis.

The Computer Science department has been a member of the CDIO initiative since 2014 and the program is organized according to the principles of the CDIO initiative. Connections to the industry are achieved in the program through Work-based education and "design-build-test" - projects integrated in the subject courses. The learning objectives that are described in CDIO syllabus, are divided into 4 sections: 1) knowledge in the discipline, 2) personal and

professional skills, 3) teamwork and communication, and 4) Conceive, Design, Implement, Operate.

Development for Mobile Platforms – 7,5 credits
Here, students practice a purely software engineering project. They are free to choose the content of the project, but only with the restriction that it must be an application running on a mobile phone. This leads to different projects for the different student groups. There is no specific project management model used in this course. At the project start the students need to write the requirements of their app as well as an estimation of the time needed for the different project tasks. The project is summative assessed at the end of the course by looking at the code and the requirements list.

Computer Engineering course – 7,5 credits
The students practice both hardware and software development in the course project, as well as agile project managing in an introductory level. Project management is a key purpose of the course and to convey the importance of agile management the related lectures are helped by an agile project management specialist with hands-on experience of agile project management in the IT-industry. A formative assessment of the project is used like in the Systems Engineering course.

Systems Engineering course – 15 credits
The main purpose of the course is to give the students a hands-on experience of prototype development of a system comprising of both hardware and software development. The project model used in the course has evolved from an iterative project model to an agile model over the years, with a formative assessment. The course has since 2018 been joined with the Bachelor Thesis course (Klonowska, Frisk, & Einarson, 2021). The students have the possibility to join the project in this course with the Bachelor thesis, which is promoted.

A significant part of various projects has always been carried out at companies in the IT industry or other IT organizations. Business projects were promoted by both universities and students, who contacted companies on their own. Since 2020, Work-Based Learning (WBL) (UHR, 2021), (Einarson, Frisk, & Klonowska, 2022) has been an integral part of the course. The WBL integration does not change the purpose of the project and the assessment in the course. It is still the responsibility of the students to find a project carried out at a company. During the last two years the university has intensified the support for the students in finding projects in the IT-industry.

Bachelor Thesis in Computer Engineering course – 15 credits
The aim of the course is for the student to develop in-depth skills with independently planning, realizing, and presenting (in writing and orally) an in-depth project within a defined area in computer engineering and technology, using scientific methods. The work takes place in pairs of two students, unless there are special reasons for doing otherwise, in connection with academic supervision. The student must define the task in writing at an early stage, conduct an analysis of the hypothetical/problem, and produce a schedule in collaboration with the academic supervisor. The students have a possibility to do their thesis at the company as well as a joint project with the Systems Engineering course described above.

QUESTIONNAIRES

Two questionnaires were sent in the end of November 2021 to both companies and students including alumni. The questionnaires were essentially divided into three parts: (1) Cooperation between students and employers in our study programmes; (2) Content of student projects; and (3) Structure and content of future cooperation. These questionnaires were also used in the second authors paper (Einarson, Frisk, & Klonowska, 2022) and only a subset of the questionnaires is discussed in this paper.

The first questionnaire consisting of 46 questions was sent to 30 contact persons in companies and organizations cooperating with our department, with 11 employers responding to the questionnaire. The companies and organizations will be referred as employers for short.

The second questionnaire consisting of 49 questions was sent at the same time to our first-, second-, and third-year students in both undergraduate programmes as well as to our alumni, who have finished the programmes during the last five years. In total, around 200 students and 200 alumni were reached. Approximately 25% of the students and alumni have responded to the questionnaire, distributed as given in Table 1.

Table 1. Number of responses from students and alumni, in total 104.

	Engineering Programme	Software Development Programme	Total
Year 1	5	11	16
Year 2	11	23	34
Year 3	4	19	23
Alumni	8	23	31

Involving first- and second-year students gave us information about future expectations from them. The third-year students and alumni gave us information about both expectations and feedback from completed projects.

QUESTIONNAIRE RESPONSE

Cooperation between students and employers in our study programmes

In the questionnaires both students and employers were asked about what kind of interaction they have participated as a part of our study programmes. The most common interaction between the students and employers is a guest lecture by a company employee, 44 out of 104 students have participated in a guest lecture. Of the 11 answers from employers only 1 company has held a guest lecture. Two students have made a study visit to a company while 25 students have made some other type of interaction, such as, “We had alumni from companies who came and held guest lectures.” and “I was brand ambassador for Consid and invited Consid to come present themselves at campus.”

Content of student projects

Out of 104 responses 8 students answered that they have participated in a project at a company during the education. Out of 11 responses 5 companies have supervised students during the thesis and/or larger project. There should be noted that the responding employers

have not supervised any of the responding students. According to the students, the project idea was equally proposed by the students and by the company.

For all companies involved in student projects, the results of the projects are used further after the project was finished, except one. Three out of five ideas for student projects were conceived within the company. The purpose of the student project where mainly product development and product tests, but also getting to know the students for eventual future employment.
The students working with a project within a company seems to be satisfied with their work. One comment is that they created a product that works, another comment is that the student got employed after the project where finished. The employers are as well satisfied with the work by the students, mainly by two reasons, firstly the result of the project was useful for the company and secondly the students were ambitious and engaged in their work at the company.

Structure and content of future cooperation
From the limited response one can see that the companies have a preference to provide student projects both in a project course or/and as a thesis in front of other types of cooperation as guest lectures and study visits or WBL. The companies answered that the ideal length of a project spans from 1 month to a full semester, which is seen in Figure 2 below. The students are interested in larger/longer projects, in average, compared to the companies.

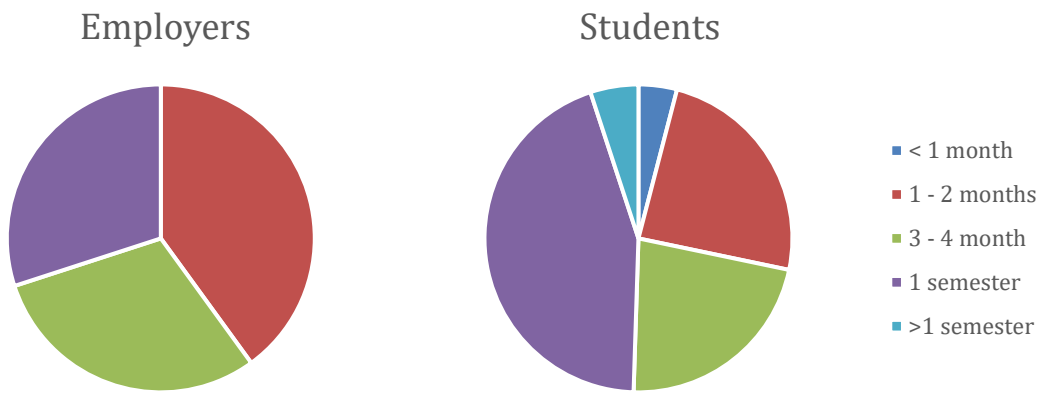

Figure 2: Comparison of wanted project length between employers (10 answers), students and alumni (99 answers). On average the students want a longer project length than the companies.

The wanted project length is broken down into study years regarding the students, also the alumni responses are separated in Figure 3 below. The project length of one semester is preferred more and more, as the student progresses through the education.

The students´ wish of future cooperation with companies are very diverse. It is a range from visits, guest lectures, internship to larger projects. A large part of the student answers expresses a wish to build contact with companies for increasing the probability of finding an employment after the studies.

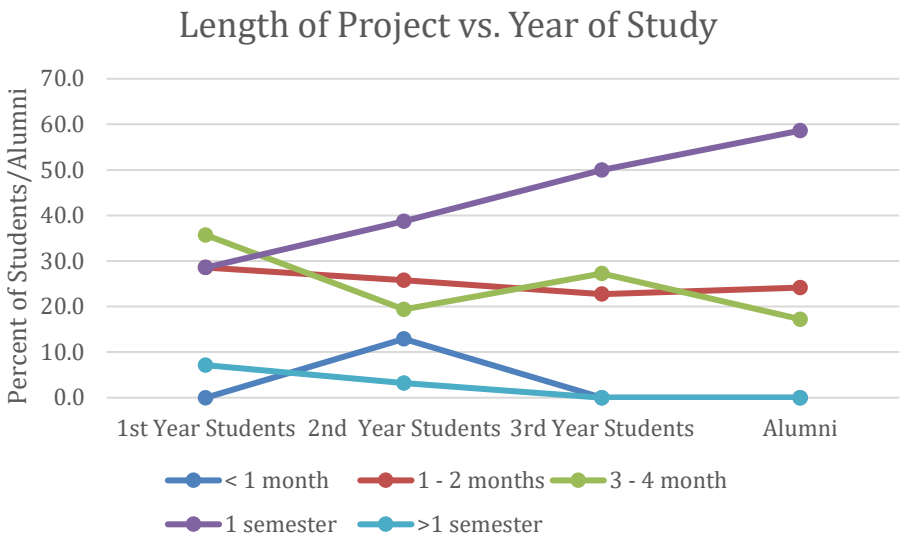

Figure 3: Wanted project length from students and alumni. The percentage wanting a project length of one semester increases almost linearly as the students' progress through the education including alumni.

The companies' preferred future forms of collaboration with students have a focus on product development and research, as seen in Figure 4.

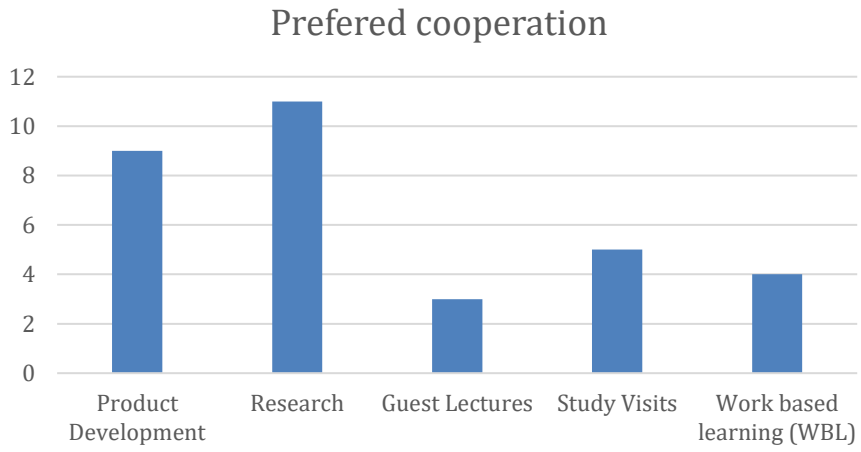

Figure 4: Company preferred forms of future cooperation.

PROGRAM EVALUATION

In 2021, HKR had carried out evaluation of all programmes through an extensive survey among alumni. The survey was sent to 1906 alumni from 14 programmes, with a response rate of 32 percent. The purpose was not only to map the alumni's establishment in the labour market and how the academic education had prepared them for working life but even how the degree goals required by the academia are used in their daily work.

Labour market questions

For the Bachelor Programme in Computer Science and Engineering, 16 out of 60 alumni responded to the survey. 87% (corresponding to 14 alumni) of the respondents are currently working, 7% (= 1 alumni) are studying and 7% (= 1 alumni) is unemployed. 33% has got a job before graduation, 53% directly after graduation (up to 6 months), 13% have not got a job related to the education. 93% answered that they have a job that corresponds to their education, while 7% (= 1 alumni) has a job that does not corresponds to the education, but the respondent answered: “No, I benefit from my education in my work”.

Education-related questions

The alumni were allowed to assess 14 academic skills: "To what extent do you use these skills and abilities in your work?" and "How well did these abilities develop during the education?" The skills are presented in Figure 5.

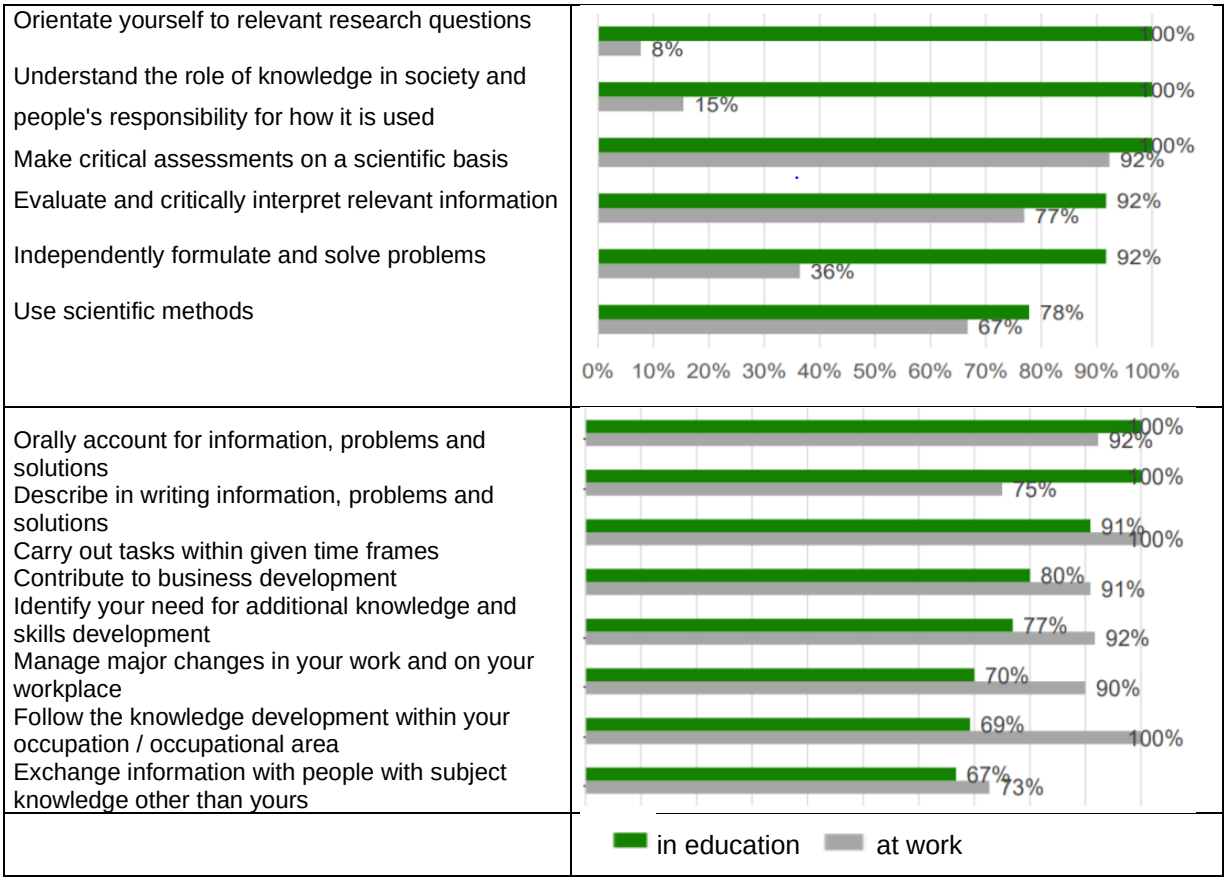

Figure 5: Academic skills, use at work and how well the education developed these.

On the question: “From the experiences you now have from work life, do you miss something in the content of the education, or would you need to train more in something?”, several answers imply a wish of more interaction with future potential employers, e.g., “Better integration with companies in the industry, and the opportunity to meet entrepreneurs / alumni” and “I would have liked to have seen some form of internship, to prepare one for how a workplace works and looks.”

DISCUSSION

The questionnaires are still open, and we are positive of receiving more answers from both employers and students. An example of inconsistent responses is, for example, regarding the guest lectures, where almost 50% of the student have participated but only 14% (1 company). We have only six responses from students who say that they have worked with a project in the industry, out of 17 responding alumni. This is clearly an underestimation, most of the degree project are taking place outside the university at a company. The last three years more than 60% of the degree project has taken place at a company or another external organisation.

A positive response is that we can see is that the results from all projects carried through at a company is used further by the same companies, an example is the evaluation of new product prototypes. Even though we only have three companies answering this question, it is an indication that the companies find the projects useful. The response rate is low can certainly be explained by the short amount of time between when companies were contacted, and today's date (*today's date is 2022-01-15, the result will hopefully be complemented with further information in a possible later version of this paper*).

CONCLUSIONS

The survey shows that both companies and students are positive about facilitating and participating in projects that are run or initiated by companies. The companies think that the project results are useful for further development and the student feels that the project work in a company a motivating way of learning how to learn how to work in "real" projects. Both companies and students think that the projects are a segway to possible future employment. From the company perspective we can see that the product development and research is the preferred collaboration with the university and student, Not saying that the other forms of collaboration is not desired.

The students want more interaction with companies and other organizations, as well as the companies want to continue the collaboration with the university and our students. The survey also shows that the students prefer longer projects, up to one semester, which is longer than the companies state. We interpret the desired shorter project time from the companies as a resource limitation. The companies say it takes between 5-10 hours a week to supervise the students, which can be a limitation for longer/larger projects.

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BIOGRAPHICAL INFORMATION

Fredrik Frisk has a PhD in Mathematical Physics and has several years of experience in teaching Computer Science, project management, and Physics. Furthermore, he has several years of experience of product development from Industry.

Kamilla Klonowska has a PhD in Computer Systems Engineering and has several years of experience in teaching Computer Science. She has also been active in developing and revising educational programs at the Computer Science department with a focus on increasing quality as well as emphasizing the academic skills of students.

Daniel Einarson has a PhD in Computer Science and has several years of experience in teaching Computer Science and Software Engineering. Furthermore, he has been experimenting with several different forms for project-based learning.

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