# THE WIN-WIN OF SYNCHRONIZING LAST SEMESTER'S COMPUTER ENGINEERING COURSES

**Kamilla Klonowska, Fredrik Frisk, Daniel Einarson**

Computer Science, Kristianstad University, Sweden

## ABSTRACT

This contribution addresses how two parallel courses during the last semester have been synchronized, where one is a course for Degree project. This is to give students a greater chance to complete the courses on time, and at the same time create a greater understanding of complicated problems. Observations have previously been made where students found it hard to take in, and finish the last semester's courses, at the same time as they complete their studies through their Degree project. Extensive revisions have been made to the parallel courses, where both basic course structures and contents have been taken into account. Clear improvements have been seen, both through course results, and based on students' comments.

## KEYWORDS

Project-based education, Degree project/Thesis work, Computer Science and Engineering studies, IoT projects, Embedded systems, Standards: 2, 3, 5, 6, 7, 8

## INTRODUCTION

The three-year Computer Science and Engineering program at Kristianstad University (HKR), Sweden, has for several years suffered from difficulties during the second semester of the third year, where students most often tend to miss significant deadlines. This semester, which is the students' last, comprises a final Degree project of 15 credits (HEC), which corresponds to half the work effort during the semester. Different approaches have been tested to give students the best possible conditions to complete the Degree project on time. On the one hand, the Degree project has been full-time during the latter part of the semester, with the first half consisting of other courses. On the other hand, the Degree project has run in parallel with other courses throughout the semester. However, both approaches have resulted in situations where the students in many cases do not complete the Degree project, and that other courses during the semester have also suffered.

A main revision of the Computer Science and Engineering program was made three years ago. The difficulties with the last semester have then also been considered. An effort has been made to develop synchronization opportunities between the courses during this semester. A big project course of 15 credits (HEC), Systems Engineering, that previously was run at the beginning of the semester, has been moved and improved so the content of the course, as well as levels of learning objectives and examination forms have been considered to suit the parallel ongoing course for the Degree project (Thesis). Students have been offered opportunities to develop and analyze advanced systems where the course Systems Engineering has been based on development and the implementation of embedded systems, while the course for Degree projects has been based on more theoretical and exploratory perspectives.

In the Systems Engineering course, the students design the systems with both hardware and software. At the same time, in Thesis course, they conduct literature studies, and investigate suitable analysis methods. Examples of projects include:
- Drones. Processors for these, as well as software to give these flying properties, are developed. Technical measurements are made, for analysis and evaluations. Measurements made are based, e.g., on the placement of sensors, and performance on technical protocols.
- Body Sensor Networks. Here, too, both hardware and software are designed to put the system into operation, and technical measurements are made to study at the usability of the system.

Synchronizing the courses has generally given good results, where the opportunity to complete the courses has increased drastically. A survey of the students' experiences has been made, and this has shown high satisfaction.

The program is clearly CDIO-oriented, which is also expressed in the programme curriculum (TBIT2, 2020). The perception is that the synchronization of courses described in this contribution, and the effects of this, further increase the fundamental values pointed out by the CDIO.

## BACKGROUND

The Bachelor Programme of Computer Science and Engineering at Kristianstad University, Sweden, is three years 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 program 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. The focus has been changed to Internet of Things (IoT). New courses were introduced to strengthen progressions in projects, mathematics, physics, programming, computer science and computer technology as well as the main specialization in IoT. 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 Degree project (see Figure 1).

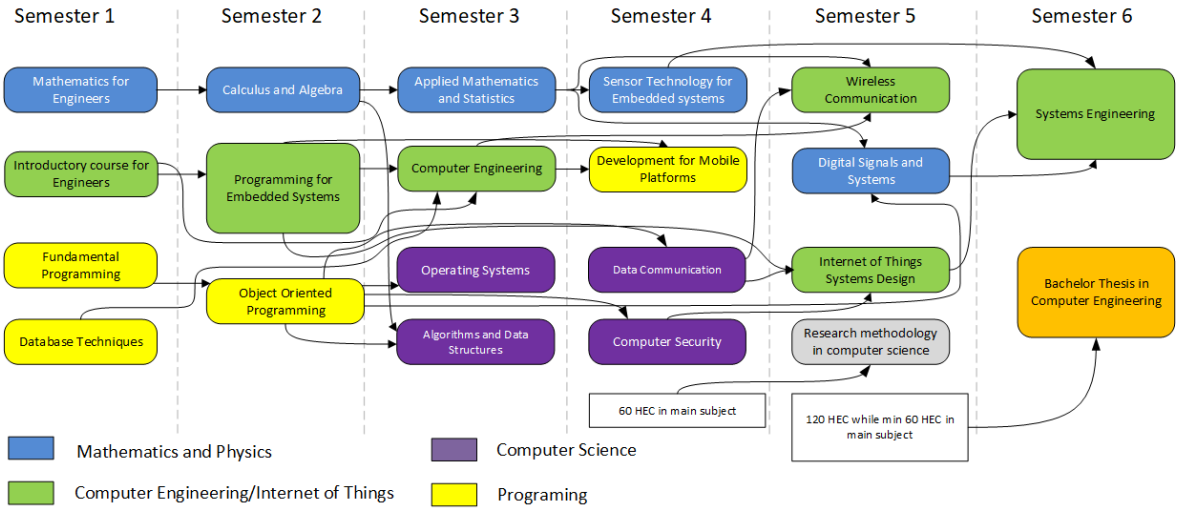


Figure 1: Bachelor Program in Computer Science and Engineering, HKR, (TBIT2, 2020).

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.

***Systems Engineering course***

The Systems Engineering course has been a part of the programme curriculum for more than ten years. During the live span of this course the main purpose of the course has always been 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. Before 2013/14 the course was running as a fulltime course during the first part of the last, sixth, semester. From 2014/15 the course was running as a half-time course, for 20 weeks.

The course is organized in accordance with the principles of the CDIO initiative. The learning outcomes are related to the four sections of the CDIO syllabus (DT336B, 2020).

The Systems Engineering course is the second and last project course within the curriculum. The first project course, Computer Engineering, is held during the second year. The formative assessment is similar to the Systems Engineering course, limited in implementation. The prototype development project involves both hardware and software aspects as the Systems Engineering course. The scope of the project is small and introductory. Both hardware and software development are present, as well as agile project managing model, but in an introductory level.

***Bachelor Thesis /Degree Project/ in Computer Engineering course***

The aim of the course is for the student to develop in-depth skills with independently planning, realizing and presenting an in-depth project within a defined area in computer engineering and technology. After completing the course, the student must:

- be able to explain and show understanding of matters within the field of computer engineering, including its scientific basis and applicable methods, along with an in-depth study of some selected part, plus have knowledge of current research issues (1)
- be able to explain their knowledge in computer engineering and technology, as well as relevant knowledge in mathematics and science at an in-depth level (2). (DT339B, 2020)

Degree project was previously running as a separate course at the end of the education, as a full-time course for 10 weeks. From 2014/15 the course was running as a half-time course, for 20 weeks, last semester.

An idea to join the last two courses came in 2017/18 with a new course coordinator of the Degree project course. The course coordinators discussed the idea with the students one month before the courses´ starts. The response was clearly positive. Most of the students chose to join both courses. As a result, 7 of 10 students passed both courses on time. Those 3 students that did not pass on time, explained that their projects were too ambitious, and they needed more time to do more experiments and measurements. These students passed their theses one year after with very good grades.

During the latest revision (2019/20), the grading was updated with a clear assessment of all learning objectives. The students receive one grade for all parts, i.e., written report, oral presentation and written and oral opposition. This facilitates work for assessing teachers and course coordinator who reports the grades in the system.

## RELATED WORK

It is important to see that educational programs should contribute to a scientific basis, as well as a high degree of employability for students. An integration of these two perspectives was addressed in (Einarson & Lundblad, 2014), where an industry-related project is seen as a case study of a scientific area being studied. This integration is carried out within the frames of a degree project of 15 credits, while the integration of two separate courses of 15 credits, as mentioned in this article, implies greater challenges, as well as greater values, with respect to, scientific basis and employability.

In most universities the Degree project course comprises 15 credits. Some universities provide separate course in research methodology just before the Degree project as well as separate project courses, also before the Degree project. For our knowledge, we did not find any university in Sweden, that combine the project and Degree project courses in computer engineering in one. There is one university (Umeå University, 2020) that combine the project course (laboratory) with a Degree project in molecular biology.

In (Hakkala & Virtanen, 2019) the authors present the structure model and visual tool for systematic thesis planning for engineering Master students at Turku University, Finland. The main concept is to efficiently bring the topic area of the thesis into focus while at the same time improving the readability, coherence and overall impact of a thesis. Teachers from Mongolian University of Science and Technology (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. The program is based on CDIO syllabus and the Degree project is the last project in this progression line.

There are as well other aspects like quality of the Degree thesis. O. Svärd (Svärd, 2014) focuses on the concept of quality of the Degree project. He posts an interesting question whether an assessment of the quality of a Degree project can be used for evaluating the quality of the entire programme where it forms a part. The subject is partly initiated by the design of the quality evaluation system in Sweden introduced in 2011. In Sweden, engineering education is discussed, among other things, in the Swedish Engineers Group, represented by representatives from all engineering educations in Sweden. Ten of them offer bachelor engineering education in computer science, while some of them are based on CDIO syllabus.

## IMPLEMENTATION

Both courses begin during the spring semester in January. The courses´ coordinators meet with students about 2-3 months earlier. During the information meeting, opportunities and difficulties are presented as well as reflections and recommendations (see Table 1) from previous year's students. The message about joining the courses is:

- Work on the same idea

- Design and build a prototype software and the hardware system in the Systems Engineering course
- Use the prototype system for research and evaluation in the Degree project course.

However, both courses are treated separately with different learning outcomes. The students are even informed that they are graded in two different ways. It is worth to mention that Systems Engineering course is the last project course in project-progression line while Degree project is the last one in an academic skills progression.

Table 1: Recommendations and reflections from students

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| "Both courses are time consuming, it is important that you do not just work on one part and forget the other. I can imagine that it is easy for the Systems Engineering course to become a major focus in the beginning - but that the Thesis is a bit on the side. But we were careful to work on everything theoretical, literature study, all writing and a clear picture of the appearance of the Thesis itself, even though we worked towards a fully functioning system in the Systems Engineering course." |
| "This is tricky. It didn't feel like that when we realized that we wouldn't finish the Degree project in time but now that everything is said and done and we finished and passed both courses I think it was a good idea." |
| "In order to manage both courses, it is good to consider both projects as separate, because the Systems Engineering took more time to get approved and start working. This will delay the thesis." |
| "Communication with your partners. Set up priority due to the different timeline. Try to finish everything ASAP, instead of postponing it.<br>We have a strong motivation to finish everything, my partner need to pursue further study(master) and I need to start working in June, so we have no choice (sadly ☹). That's the driven power for us to try to finish everything. It was a bit hard due to the COVID situation and also high volume, but both the teachers from the university and the company are really helpful and understanding." |

### *Systems Engineering Implementation*

The teaching in this course consists of lectures, laboratory exercises and mandatory project meetings, and furthermore help sessions (informal project meetings). The course has two parts, where part one consists of lectures and laboratory exercises. The purpose of part one is to give the students practical experience of hardware design and manufacturing together with a lecture series in project management.

The second part consists of mandatory project meetings and help sessions (informal project meetings). The mandatory project meetings evenly distributed over the whole semester. The seven project meetings are assessed in connection with the meetings themselves, thus giving the student instant feedback of their progress in the project. This is the main procedure for the formative examination which is a part of this course.

The course consists of three examinations, hardware development, software development and project management. The students can by themselves decide which grade they are aiming for, regarding the hardware and software development examination. Together with the examining teacher, the student group decide the hardware and software requirements for the project. The grade is predetermined depending on the extent of the requirements. Thus, the students are well aware from the beginning of the course how to archive the different grades.
The project management assessment is done continuously during the course run in conjunction with the mandatory project meetings, i.e., this assessment is not predetermined (if

the agreed requirements are fulfilled) as the other two, instead it assesses the whole project cycle.

The students conduct tin soldering, design, and prototype manufacturing of printed circuit boards during the hardware development part of the course. The Software development part incorporates software for several separate embedded units, where the units communicate wirelessly. These both parts include design, implementation, test and integration of software modules and hardware modules. The project management part embodies agile project planning during the course, written documentation, and a final presentation of the project.

***Degree Project Implementation***

The course is conducted in the form of an independent project (Bachelor thesis / Degree project). The work takes place in pairs of two students, unless there are special reasons for doing otherwise. This includes independently planning, conducting, and reporting back an empirical research study both in writing and orally. In connection with the Degree thesis project, the students receive an academic supervision. The students must define the task in writing at an early stage, conduct an analysis of the hypothesis or problem description and produce a schedule in collaboration with the academic supervisor. The students have also a possibility to choose to do the thesis at a company. In that case the students have also an external supervisor. Each Degree project is assigned also an examiner at HKR.

The course coordinator coordinates the course with all involved persons: students, supervisors, external supervisors and examiners to allow the Degree projects being carried out successfully. The responsibilities of the course coordinator include informing students about the policy and guidelines for the Degree projects, where they can find information about the course, as well as organizing and implementing the activities of the course (submission deadlines for project ideas, project plans, mid-way seminar and final presentation). The course coordinator acts also as a supervisor and examinator. The main challenge for the course coordinator is a communication between all partners, i.e., students and teachers. The course coordinator discusses each project plan as well as each thesis with both the supervisor and the examiner.

The course material consists of a document called *Study guide*, where students find all important dates (deadlines), description of all roles (and responsibilities), explanation of course´s contents as well as guidelines to written report, presentation and opposition. To help students, the course page consists the examples of theses from previous years.

According to the Study guide students should:

- Develop a project idea and submit it in time (with the support from course coordinator).
- Develop a project plan based on the project idea and submit in time (with the support from supervisor).
- Discuss with the supervisor to decide how the supervision will be implemented.
- Keep regular contact with the supervisor, report the progress and discuss encountered problems.
- Send the initial report draft (60% of the work) in good time (2-3 weeks before midway seminar) to the supervisor for feedback/comments. Based on the recommendation from

the supervisor, upload for the midway seminar. It is also recommended to do an oral ***self-evaluation*** based on the learning outcomes of the course.
- Discuss with the supervisor on project report outlines at early stage to make sure that the report is well structured and organized.
- Do the ***self-evaluation*** based on the learning outcomes of the course and send the report draft together with the evaluation to the supervisor (latest one week before the final upload). Based on the recommendation or feedback from the supervisor, upload the final presentation.
- Submit various reports (mid-way seminar, final presentation and opposition reports) in time.

A self-evaluation is an important document that mainly helps students with the formality check, if all parts of the thesis are fulfilled according to the Degree project plan, if the thesis meets all the learning outcomes, and if it is in acceptable status and ready for presentation.

## INVESTIGATION AND RESULT

In recent years, we observed that engineering students graduated but with a certain time delay. Since we did not have many students on the program, we wondered the reason for this delay and how can we improve it. In Sweden the students evaluate the course, but even in this evaluation we could not find any hints for improvement.

### *Investigation 1: Results from both courses during last 9 years.*

During 2012–2014 both courses were offered as full-time studies, where the Systems Engineering was given before the Degree project. A reason behind that structure was that the students could concentrate only on one course during the time. However, students could not finish Degree project on time, mainly because 4 of 10 weeks were waiting time for an assessment of the project plan as well as the uploading final version two weeks before the presentation. It was not possible to go through literature study, implementation, experiment, measurement, analysis and summarizing the theory in practice in a written report during 6 full-time weeks. Most of the students did not catch a deadline for the first presentation.

From 2015 – the courses were run in parallel. For the Degree project, the waiting time was the same as previously, but the students had 16 half-time weeks (=8 full-time weeks) to work on the thesis. We could observe, that because the examination for Systems Engineering was held before the summer, the students put more efforts on this course and therefore more students finished Systems Engineering course compared to the Degree project course.

During 2015–2017 Degree project had three examinations possibilities: two before the summer and one during the autumn. From 2018 one examination before the summer has been moved to after the summer (to give the students the opportunity to gain access for the master's programme).

Figure 2 shows the number of students that passed both courses. There are three staples, the first (blue) represents Systems Engineering course, the second (orange) and the third (grey) represent Degree project with "Thesis - same year" (all three presentations) and "Thesis - later" (later year presentation) respectively. There are more students that completed Systems

Engineering course. Only in 2017 all students passed both courses “on time”, i.e., in the same year. However, these students presented the Degree projects in the last, autumn presentation.

From 2018 the students have a possibility of joining the courses. Already in 2018 most of the students presented the thesis on time. As mentioned, three remaining students put too many efforts on themselves and presented the theses one year after. We could observe similar behavior of ambitious students even during the 2019 presentations. In 2020 most of the students follow the recommendations from older students and we could see that most of them presented the thesis on time.

***Investigation 2: Survey***

The survey was conducted in the Spring term 2020. All engineering students were asked for a reflection after the presentation of the thesis. Furthermore, 8 students completed the survey. The overall reflection on merging both courses was very positive. The students agreed that it was a very good idea because they could concentrate on only one subject. The biggest challenge was to complete both courses on time. It is interesting to mention that the students agreed that if they were to repeat the courses, then they would do the same. Table 2 presents feedback from students about benefits and drawbacks of joining the courses.

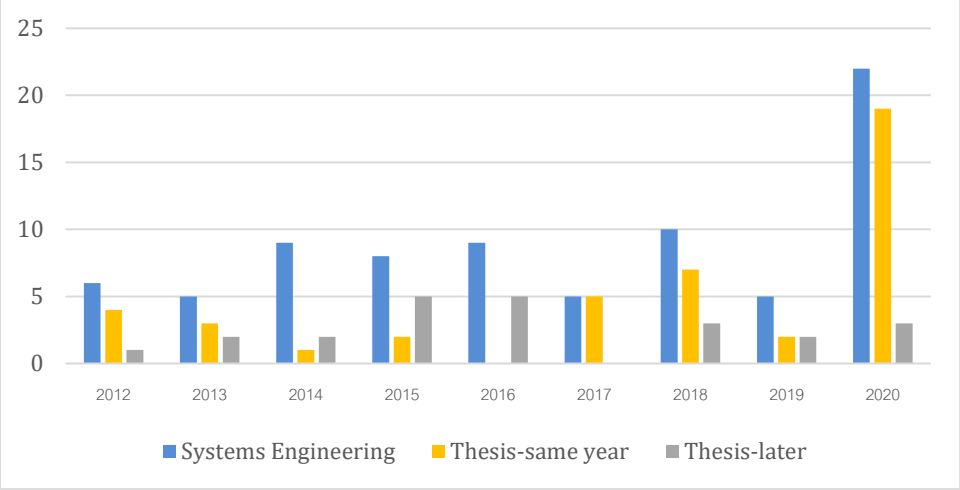


Figure 2: Number of students that passed two courses

Table 2. Benefits and drawbacks of joining the courses

| Benefits | Drawbacks |
|---|---|
| Yes, because it's fun to really be able to immerse yourself in one and the same area, to be able to plan the entire semester with a purpose, and the successes become clear. | No, because it can be too demanding, hardware is difficult, and a lot can go wrong. In theory it is easy, but in practice it can be tricky and sometimes impossible - and in some cases absolutely not as you had imagined. |
| The benefits we observed was that we could spend more time thinking about the topic of the thesis. We got a lot of insight while working on the Hardware as much as when we were doing literature studies. This means we became well versed in the whole topic the limitations and needs of our project. This is why our thesis ended | The drawbacks would be that if we failed one, we would very likely fail the other. As the two projects go hand in hand and the thesis depends on us having two functioning devices, we were taking a big risk. If we failed to finish the hardware it would be impossible to progress and evaluate its performance. |

| | |
|---|---|
| up lengthy as well because there was a lot of insight and knowledge we learned while working on the subject. | |
| Able to focus full time on one project.<br>Go deeper in one subject instead of half depth on two projects. | It was hard two divide the project in two, to separate what belonged to the SE and what belonged to the thesis. |
| For joining the courses together, we think it could be beneficial as we believed that it could give us more practice over multiple blades. | However, to be honest, the time that we spent on the courses have been way much more than we expected, sometimes, we have to study for more than 12 hours and even study during weekends (not kidding). |
| We think with the combination, we can save some time and effort on collecting information, carrying out the research to a deep Degree.<br>We believed we definitely benefit a lot from the joint project, especially by working with the company, the social and business experience benefit us a lot and with the combined course, the research can be carried much deeper and wider in some Degree. | |

## SUMMARY

This contribution addresses problems related to the completion of a Computer Engineering program. Revisions of that program have been made, where this contribution in particular focuses on a conscious synchronization of courses during the last semester. By having a project course in parallel with the thesis, technical/practical aspects are integrated with more scientifically oriented aspects, and where a larger project connects these aspects. The results have shown a positive outcome in terms of number of students completing the last semester, as well as the quality of the performance. Furthermore, a survey shows satisfaction among the students, where the following quote gives a good summary: *In the end, it was a really good summary of all the courses […] included in our program. You got proof that you have been able to use the knowledge you have learned over the past 3 years - and done a big and demanding project with it all*. As we aim to push the students to conduct the courses, system engineering and thesis, outside the university in companies, we plan to involve these companies in future evaluations of the courses.

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## BIOGRAPHICAL INFORMATION

***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.

***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.

***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.

***Corresponding author***

Dr. Daniel Einarson
Kristianstad University
Elmetorpsvägen 15
291 88 Kristianstad
Sweden
+46 -44 203177
daniel.einarson@hkr.se

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