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## Engaging Students Through Innovation In Computer Science Education

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# ENGAGING STUDENTS THROUGH INNOVATION IN COMPUTER SCIENCE EDUCATION

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## ABSTRACT

When an important course *Entrepreneurship and Innovation* is cancelled, it is still possible to incorporate innovation into the programme and provide students with opportunities to enhance their specific academic skills. This contribution addresses how the innovation activities have been implemented in two bachelor programmes in computer science at Kristianstad University in Sweden.

The survey results shows that the students wish for the university to continue offering these innovation modules and that they encounter similar modules in upcoming courses. The students felt that the module increased their understanding of the subject and their perception of their own skills.

## 1 INTRODUCTION

The goal of the innovation activities is to equip students with essential skills and abilities like developing technical and analytical skills, communication, collaboration,

problem-solving, critical thinking, and creativity to prepare them in their professional role, to actively contribute to their workplace and work to identify and find innovative solutions to societal challenges.

*How can these skills be effectively integrated into the programme(s) in the absence of a dedicated course?*

To achieve this goal, the programmes provide project-based learning to enhance the learning experience for students and, additionally, include the events like *Imagine* or *Hackathon*, where students work in teams to develop innovative solutions to complex problems. *Imagine* event provides an opportunity for students to showcase their skills and creativity and receive feedback from experts in the field. It is offered at Kristianstad University several times a year with different focus areas linked to the University's profile area of environment, health and water, which for computer science students give a chance to work interdisciplinary. *Hackathon* event is provided by older students and the goal is to challenge and encourage younger students in programming.

By providing students with practical experiences and exposure to modern technologies and teaching methodologies, the programme prepares them to navigate the ever-changing demands of the workforce. The incorporation of team-based learning and events enhances students' collaboration and creativity, providing them with the skills (effective communication, leadership, project management) they need to succeed in the modern workplace.

## 1.1 Innovation

Many definitions and interpretations of innovation are used in different contexts and disciplines. The most widely accepted definition of innovation is described in the Oslo Manual [1] as:

*“An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.”*

([1], line 146, p.46)

Baregheh et al. [2] present a comprehensive study based on comparison of 60 definitions of innovation collected from various disciplines. Based on that they propose a following diagrammatic definition:

*“Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace.”* [2]

The definition of innovation presented by Baregheh et al. [2] is most relevant to computer science students because of its “multi-stage process” as well as it emphasizes the importance of transforming ideas into new or improved products, services, or processes. This aligns with the goals of many projects and students’

activities as HackaThon and Imagine (described below), which involve creating new software or to meet user needs or solve problems.

## **1.2 Hackathon**

A hackathon is an event, usually over a short time such as 24 or 48 hours, where programmers, developers, designers, and other technology enthusiasts engage in rapid and collaborative engineering, typically in a competitive setting. Participants work in teams to create solutions for specific challenges or to develop innovative applications, often with a focus on a particular theme or goal. The goal of a hackathon is to encourage creativity, innovation, and collaboration among participants, and to produce a functional prototype or finished product by the end of the event. Hackathons can be organized by companies, educational institutions, government agencies, or other groups, and are a popular way to promote technology education, entrepreneurship, and innovation.

## **1.3 Background**

Kristianstad University is a small but dynamic university that strives to be among the most attractive universities in Sweden. The university's goal is to strengthen its reputation as a high employability for students and gain recognition outside of Sweden. To achieve this, the university has implemented various measures such as worked-based teaching across all programs and internationalization, which includes, among other things, adapting programs to student and teacher exchange. In addition, the university has established academic tracks, sustainable development, gender equality and innovation.

To comply with the university goals, the computer science programmes are revised around every three years. Students, alumni as well as the companies have a big impact in these revisions.

### **1.3.1 Entrepreneurship and Innovation (2011 – 2022)**

The course Entrepreneurship (IE520A) was introduced for the 3<sup>rd</sup> year computer science students back in 2011 because of a revising the programmes with adaptation to the university's vision. In 2015 the course has been revised by adaptation of Innovation (Entrepreneurship and Innovation, IE300A). This course was taught until 2022 with small revisions (IE301C)<sup>1</sup>. Unfortunately, with new revision and more focus on computer science, the course was cancelled. However, innovation part became implemented in new programmes in a new way – as an innovation track.

The main question was whether and how it is possible to incorporate innovation into the programme when a course *Entrepreneurship and Innovation* was discontinued. What should be included and excluded.

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<sup>1</sup> [Course syllabus - Entrepreneurship and Innovation - 7,5 credits - IE301C , English | HKR.se](#)

## 1.4 Related work

Innovation at higher education brings also different views. In OECD Report from 2016 [3] can we find outcomes of different projects, like “Innovation Strategy for Education and Training”, “Innovative Learning Environments”, and “Open Education Resources”. Here the focus lies on innovation / digital technology for learning, e.g. innovative pedagogic models; simulations as a low-cost access to experimental learning; e-learning; international collaborations; as well as for implementing and evaluating innovation in the education system.

Hoidn et al. [4] review the effectiveness of problem-based learning (PBL) compared with traditional approaches in higher education teaching for developing skills for innovation. The report explores the extent to which PBL can develop discipline-specific and transferable skills for innovation like social and behavioural skills such as motivation, interest, self-confidence, self-directed learning and teamwork.

Kumar et al. [5] discuss how educators straggle to improve, re-invent existing courses, re-organize majors and carve out new majors. The authors present in short some of the innovations that have been introduced into the undergraduate Computer Science curriculum. In most cases the students do groups activities and/or projects.

Daimi and Rayess [6] shows an importance of Entrepreneurship course in the curricula of Computer Science and Software Engineering education. They motivate that “computational thinking will govern the process of innovation to produce new software products and technologies, and entrepreneurial thinking will establish the foundations for marketing these products and technologies.” The authors introduce a design of a software entrepreneurship course, its rationale, description, objectives, outcomes, assessment and present case studies and projects. The goal of the course is to bridge the gap between creating products and creating marketing opportunities.

Zhang and Dong [7] present a need of innovation in teaching in China as three aspects: “teaching reform, training system and a platform for industry-university-research cooperative education”.

To consider innovation as a process, it is crucial to provide training to students from their first course, and it is equally important to engage and motivate them right from the start. An interesting study about the engagement of first-year students in large courses during the covid-19 was done at Swedish university [8]. It explores two successful cases of how active learning, togetherness and engagement can be created. The authors experienced that the students had actively participated in the arranged activities and the course passing rate was higher compared with the face-to-face teaching. The course evaluation also showed that the students were satisfied with course contents and various course activities.

## 2 METHODOLOGY

### 2.1 Action Research

Implementation of innovation activities is based on the action research (see Fig. 3) where a group of teachers involved in it discuss and improve the process in regular meetings.

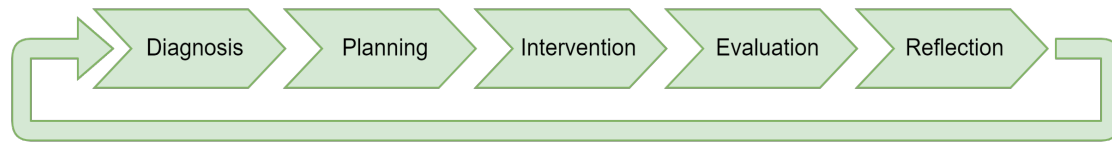


Fig. 3. The cycle of five stages in action research. [9]

### 2.2 Survey

At the end of the course that was held in Spring term of 2023, a survey was distributed to the students. 45 out of the 60 participating students responded.

## 3 STRUCTURE OF COMPUTER SCIENCE PROGRAMMES WITH INNOVATION TRACK

The following figures (Fig.1, Fig.2) show two computer science (CS) programmes with marked courses that includes innovation activities. The courses marked with the dots are the courses where including innovation aspects is optional. In both programmes, the marked courses include the individual or group projects.

	Autumn Term		Spring Term	
1st Year	Introduction to Computer Science	Object Oriented Programming	Methods for Sustainable Programming	Database Technique
	Fundamental programming	Mathematics for Computer Science	Discrete Mathematics	Agile Software Development
2nd Year	Data Communication	Algorithms and Data Structures	Backend Development	Project in Full Stack Development
	Operating Systems	Computer Security	Frontend Development Techniques	Mathematical Statistics
3rd Year	Machine Learning	Development of Mobile Applications	Software Engineering	
	Research Methodology in Computer Science	Big Data Analytics	Bachelor Thesis in Computer Science	

Fig. 1. Bachelor Programme in Software Development<sup>2</sup>

<sup>2</sup> [Programme syllabus - Bachelor Programme in Software Development - TBSE2 , English | HKR.se](#)

	Autumn Term		Spring Term	
1st Year	Introductory course for Engineers	Object Oriented Programming	Calculus and Algebra	Database Technique
	Fundamental programming	Mathematics for Engineers	Programming for Embedded Systems	
2nd Year	Data Communication	Algorithms and Data Structures	Computer Engineering	Wireless Communication
	Operating Systems	Computer Security	Applied Mathematics and Statistics	Sensor Technology for Embedded Systems
3rd Year	Internet of Things Systems Design	Development of Mobile Applications	Systems Engineering	
	Research Methodology in Computer Science	Machine Learning with Data Acquisition	Bachelor Thesis in Computer Engineering	

Fig. 2. Bachelor Programme in Computer Science and Engineering, Specialization in the Internet of Things<sup>3</sup>

### 3.1 Development of Mobile Applications course, DA324A<sup>4</sup>

The course Development of Mobile Applications is offered to both programmes. It includes lectures, labs, and a group project. The aim with the course is to teach students Android development and how to apply that knowledge to real-world problems. During the project work, students are expected to utilize their innovative skills to create Android applications that are useful for society.

The project work is conducted in collaboration with the university's department, which primarily focuses on connecting the university with society through an event/workshop called **Imagine**<sup>5</sup>. All programmes offered by the university are eligible to participate in the Imagine workshop, which means that there are many innovative areas with various issues that university students can work on.

At the Imagine workshop, one representative from a company joins a student group to collaborate on designing features that would address a particular issue faced by the company or society. However, it is also possible for representatives from other area of society, such as hospital personnel, to contribute by presenting and discussing issues in their respective environments. In this way, students can work to find innovative solutions to a variety of challenges.

The following are some examples of Android applications developed based on the issues presented during Imagine event:

- In 2018, computer science students joined Imagine workshop with nursing students to come up with innovative solutions for hospital care<sup>6</sup>. The collaboration resulted in the

<sup>3</sup> [Programme syllabus - Bachelor programme in computer science and engineering - TBIT2, English | HKR.se](#)

<sup>4</sup> [Course syllabus - Development of Mobile Applications - 7,5 credits - DA324A, English | HKR.se](#)

<sup>5</sup> [Imagine – En innovationshöjande aktivitet för studenter | HKR.se](#) (in Swedish)

<sup>6</sup> [Datavetare ger draghjälp på ToY Imagine | HKR.se](#) (in Swedish)

development of several various applications, and an example of one such application can be found here<sup>7</sup>

- Despite the pandemic, the Imagine workshop was successfully conducted online<sup>8</sup>.
- The workshop held this year involved both of our data science programs and included 12 companies with 15 app ideas or questions. The quality project was completed by 15 student groups, each comprising four students, who developed a mobile application as part of their coursework.<sup>9</sup>

### **3.2 Systems Engineering course, DT337A<sup>10</sup>**

The Systems Engineering course is the second and last project course in the Engineering curriculum. This course is conducted concurrently with the thesis, and the students work on the same project in both courses but focusing on different aspects. In the thesis course, the emphasis is on the scientific part, while the systems engineering course focuses on prototype development. This construction allows the students enough time to develop an innovative prototype as well as evaluate it within the thesis. The prototype development project involves both hardware and software aspects. The students have the possibility to work on the project in an industry as well as working by themselves at the university. Both industry projects and independent students' projects are often innovative.

Examples of projects include:

- Smart heating control: This prototype is used to control heat to the facilities by an actuator and measure system temperatures. The method used to control the system was a deep learning model implemented in the prototype edge device classifying the system's different behaviours, preheating, heating and cool down. The prototype was installed in a real house and evaluated for several weeks.
- Preventing mould damage in attics: This prototype notifies property owners when environmental conditions in attics are favourable for mould growth. It was tested on site in an attic.

### **3.3 Other examples of engaging students**

#### **3.3.1 HackaThon at HKR. 12<sup>th</sup> of November 2022, Saturday, 14:00 – 18:00.**

This hackathon was organized by senior CS students and took place on campus and online. The event was aimed at all CS students. The tasks were adapted so that everyone could do at least one task. Students started with an easy task and slowly progressed to more difficult ones. All the tasks were designed by a senior student, who described the experience as “a great learning opportunity for me.” The students could participate individually or in groups and could choose any programming language. The invitation letter encourages first-year students not to be intimidated by

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<sup>7</sup> [EldHelp gives the elderly independence everyday, English | HKR.se](#)

<sup>8</sup> [Förbättrad miljö och minskat matsvinn prisas på innovationsevent | HKR.se](#) (in Swedish)

<sup>9</sup> [Studenter skapar app för global pant mot nedskräpning | HKR.se](#) (in Swedish)

<sup>10</sup> [Course syllabus - Systems Engineering - 15 credits - DT337A , English | HKR.se](#)



difficult tasks, but to view them as opportunities to solve creative challenges and learn from the experience.

Senior students described the hackathon as a social coding event that brought students together to solve coding tasks. The level of experience didn't matter, the focus was mostly on having fun and challenging themselves with like-minded people.

Feedback from the 1<sup>st</sup> year student: "The hackathon was fun and gave me insight on how to think in different ways regarding coding. And I gained a lot of experience from solving the different tasks. I did learn how even in a team we had our own ways of thinking and coding to reach the result." Feedback from the senior student: "I think it was a successful event just like the year before. [...] Those who participated truly enjoyed it and thanked us for getting to have this opportunity to not only experience working in teams but also getting to try more challenging tasks with their knowledge. Most participants were first year students, and we helped some who asked for help to think through the problems in different ways to find the way towards a solution."

### **3.3.2 The FoodHack. 13-15th of March 2023, Monday – Wednesday, Krinova<sup>11</sup>**

The Food Hack<sup>12</sup> is a 48-hour long innovation competition and food conference for the global food community initiated by Krinova. This year's Food Hack theme was on Data-Driven Food System<sup>13</sup>. The goal was to explore the opportunities of data as an underutilized tool within the food and agriculture sector. During the first day the participants were invited to three talks: "Tech and data driven food system – what it means and how will it change what we eat and grow", "How data is transforming agriculture", and "Helping the consumer care about food". Thereafter, the participants worked in teams to set up projects boosted by the latest research and experienced mentors, all in the spirit of challenge-driven open innovation.

Admission to Food Hack was free, and all meals to nourish the mind were included from Monday lunch until Wednesday lunch, along with accommodation in dorms (participants were required to bring their own sleeping mat and bedroll). The best hack-teams had the opportunity to win prizes worth 50,000 SEK.

Feedback from one student: "I totally recommend this experience. I think that you only not will gain new knowledge, but also friends. The tutors are amazing. It's people that inspires you. A new experience, I recommend. Thank you."

### **3.3.3 Other events**

The University and the Computer Science department offer students additional events throughout the academic year, such as the Future Fair, Research Day at CS, and Career Fair. These events provide students opportunities to kick-start their job

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<sup>11</sup> [About us - Krinova - Krinova](#)

<sup>12</sup> [Food Hack – By Krinova](#)

<sup>13</sup> [Food Hack by Krinova 2023 - YouTube](#)

search, establish connections with potential employers, and discover topics for course projects and their degree thesis.

#### 4 RESULTS - SURVEY

The survey shows that the students wish for the university to continue with this module (6.1 in average on a 7-point scale) and that they encounter similar modules in upcoming courses (5.5). The students felt that the module increased their understanding of the subject (5.7) and their perception of their own skills (5.8).

The students reported being motivated and engaged in the course module. After analyzing the survey results, we believe that the reason for the success was the students' collaboration with companies on real-world tasks, which were inherently engaging and stimulating. In addition to programming the application and utilizing technical knowledge they had acquired throughout their years in the program, the students also acted as consultants, which is a role that many of them will hold in their future careers. This experience helped strengthen the bridge between academic studies and professional work. Two particularly positive outcomes emerged from the course module: one of the actors purchased the prototype app that the students had built, and another actor will be using the prototype app in a research project.

The students not only received grades in Android programming, but also gained knowledge in meeting the customer, maintaining contact with the customer, and acting as consultants, which is a valuable addition to their resumes.

One wish and hope from the teaching staff was that the students would continue with their business projects in subsequent degree projects. One group made this choice and continued developing, investigation and evaluation as a degree thesis, where the company stayed as a secondary supervisor. Their product is currently in use.

#### 5 SUMMARY

Even if an important course *Entrepreneurship and Innovation* was cancelled, it was still possible to incorporate innovation into the programme and provide students with opportunities to enhance their specific academic skills. The examples show how students' creativity develops through their studies. Nevertheless, the entrepreneurship part is missing from the programme. On the other hand, Krinova offers and helps students an opportunity to do start up their own business.

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