2023

A Three-Year Academic Track Towards Literacy In Sustainable Development - A Computer Science Study Program Case

Kamilla KLONOWSKA
Kristianstad University, Sweden, kamilla.klonowska@hkr.se

Marijana TELJEGA
Kristianstad University, Sweden, marijana.teljega@hkr.se

Daniel EINARSON
Kristianstad University, Sweden, daniel.einarson@hkr.se

A THREE-YEAR ACADEMIC TRACK TOWARDS LITERACY IN SUSTAINABLE DEVELOPMENT - A COMPUTER SCIENCE STUDY PROGRAM CASE

K. Klonowska
Kristianstad University
Kristianstad, Sweden
0000-0002-5779-381X

M. Teljega
Kristianstad University
Kristianstad, Sweden

D. Einarson
Kristianstad University
Kristianstad, Sweden
0000-0002-6519-5051

Conference Key Areas: Embedding Sustainability and Ethics in the Curriculum, Lifelong Learning for a more sustainable world

Keywords*: Computer Science, Academic and Sustainable development tracks*

ABSTRACT

The 3-year Bachelor Programme in Software Development study program at Kristianstad University, Sweden, aims to integrate not only academic competencies and skills in subject courses but also critical thinking skills on how Computer Science can contribute to achieving the sustainable development goals.

Starting from an understanding of the sustainable development goals, students begin a process of designing and implementing applications for some specific goals. Through participation in various activities, students exchange the ideas and perspectives, and are challenged to consider multiple solutions to complex problems.

The students' critical thinking, communicative abilities, and the ability to solve problems both individually as in groups are developed in a clear progression through the education.

This contribution aims to provide an overview of the sustainable development track in the programme, as well as in-depth presentations of some of the courses covered. The main objective of the study was to gather students' perspectives and feedback on the relevance and importance of sustainable development goals in the context of computer science. Students' views have been evaluated through the survey.

1 INTRODUCTION

This study presents an overview of the sustainable development track within the Software Development program as well as detailed insights into selected courses. Furthermore, students´ perspectives has been conducted and evaluated via a survey.

1.1 Background

The Bachelor Program in Software Development at Kristianstad University, Sweden, is three years programme and is provided for both national (Swedish) and international students. In addition to preparing the students to further studies, the university aims to ensure that they become highly employable. To achieve this goal, several changes in the programme have been implemented during last 10 years.

A main revision of the program was made during 2013-2014 where the Computer Science department has been a member of the CDIO initiative [1] and the program was organized according to the principles of the CDIO initiative. Connections to the industry were achieved in the program through work-based education and "design-build-test" - projects integrated in the subject and project courses. Further changes were made to the program like a clear progression between the courses (e.g., mathematics, programming and software development skills) as well as a progression in academic skills. The implementation of academic skills has been named the *academic track* [2]. It is a systematic development of general competences that create important prerequisites for the development of the scientific approach, which in turn led the students being able to assimilate the subject-specific and reach the degree goal of the education. The academic track thus became a tool that created a clear connection between the general and the subject-specific. In Spring 2018, employees from Computer Science department participated in the university pedagogic course "Teaching for sustainable development". As a result, the subject of "sustainable development" was implemented to the programme in Autumn 2018. Integrating *sustainable development track* in the program was created in similar method as when integrating the *academic track*. New revision of the program was done in 2020 by implementing applied computer science with machine learning and a new course "Research methodology in computer science" to ensure research connection and raise students' scientific attitudes as well as prepare students for the

bachelor thesis. The current version of the programme with sustainable track is presented in Section 3.

1.2 Literature Review

The integration of SDGs in computer science education is widely discussed around the world. Nwankwo et al. [3] present six various areas in which CSE (Computer Science Education) and ICT (Information and Communications Technology) are applied for sustainable development. They point the challenges and barriers of the deployment of ICT solutions towards the realization of SDG in higher education and technology development in Nigeria. Gordon [4] describes how the four priority ideas identified by the UK government can be integrated into higher education in computer science. The author gives the examples of the topics that provide opportunities for discussion in the classroom, e.g., the practical and ethical aspects of computer use, consider pros and cons from a societal perspective, security aspects, etc. Argento et al. [5] present how academics representing different disciplines, with specific traditions and characteristics, face the sustainability challenge. The case of University in Sweden illustrates the experiences shared by six colleagues, representing different disciplines (inclusive computer science), engaged in implementing sustainability in their courses and programmes. Mawonde et.al [6] show a case study of the University of South Africa from the distance education perspective. The research revealed several practices that align with SDGs in teaching, research, community engagement and campus operations management. Fisher et.al [7] survey the integration of environmental and societal sustainability into computer science curricula at colleges and universities around the world. They present two integration levels: the course-level, where the computer science courses focus on topics at the intersection of computing and sustainability, and the component-level, where the sustainability themes are introduced as the course components, such as lectures, exercises, and projects. Further, the authors speculate on the future of sustainability-themed computer science education, including curriculum-level integration. Here, they talk about a specialized track with courses within the track differentiated by sustainability topics. They think that computational sustainability majors will be designed around frameworks of evidence-based decision making.

2 METHODOLOGY

2.1 Action Research

Creating and implementation of academic and sustainable development tracks is based on the action research (see Fig. 1) where a group of teachers involved in it discuss and improve the process in regular meetings.

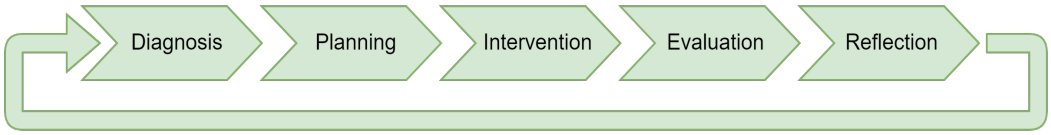

Fig. 1. The cycle of five stages in action reseach [8].

2.2 Survey

The survey was conducted in the Spring term 2023 for 1st year students that already had two courses involved in sustainability track. Students were asked if they were familiar with the subject of SDG (sustainable development goals) before joining the university and their thoughts on SDG in relation to CS (computer science) programme as the amount of information included in these two courses.

3 OVERVIEW OF SUSTAINABLE DEVELOPMENT TRACK

Fig. 2 presents the current version of the programme. The sustainable development track comprises five courses: one introductory course and four project courses. Yellow-marked courses belong already to the track while the green-marked course (a new one in the programme) is under reconstruction to be also applied in the track. Additionally, there is a final course in the program, the bachelor thesis, which allows students to choose a sustainability aspect, although it is optional. However, reflection on societal and ethical aspects in the thesis is mandatory.

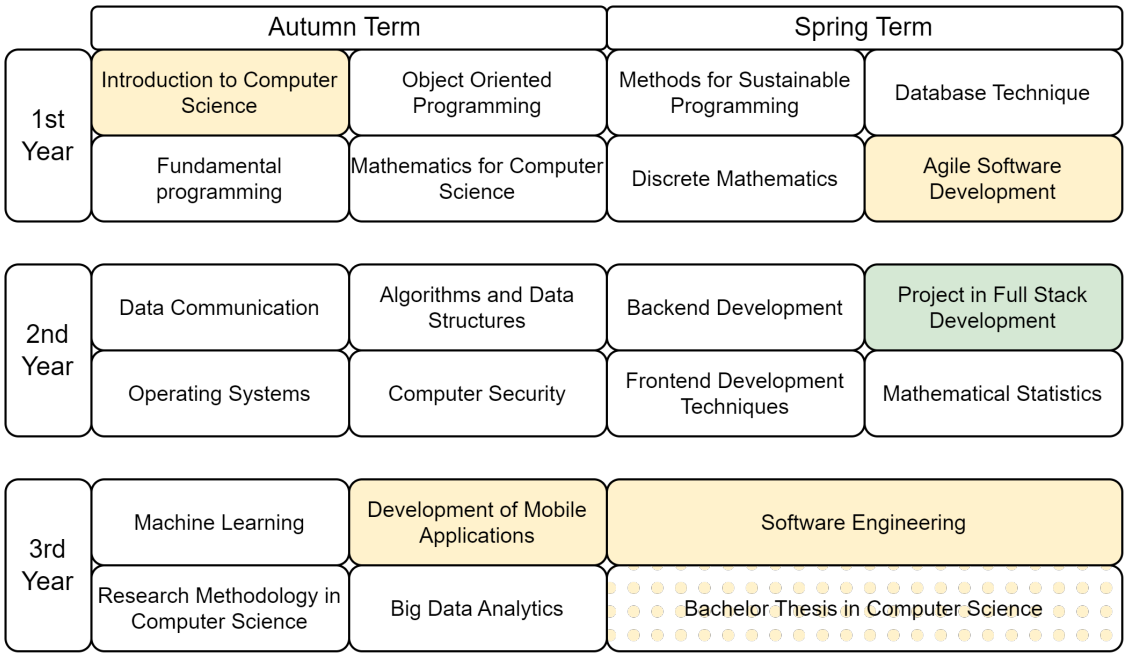

Fig. 2. Bachelor Programme in Software Development, HKR[1]. Marked courses are the parts of the sustainable track.

Table 1 presents an overview of the moments in the courses that include sustainability aspects, along with information about students' work and examinations. It also indicates which learning outcomes are included in the course syllabus that covers the sustainable development track.

[1] Programme syllabus - Bachelor Programme in Software Development - TBSE2 , English | HKR.se

Table 1. Sustainability track in details

Course	Moment in the course	Students` work / examination	Learning outcome(s)
Introduction to Computer Science	Guest lectures: AI in computer science; AI for Sustainability; SDG and Ethical aspects; Literature search; Academic writing; Peer review;	Individual academic report on the subject: “AI in research with a focus on SDG and Ethical Aspects” Practice reviewing each other's reports; Individual presentation and discussion in group during the seminar.	- be able to make simpler assessments with regard to relevant social and ethical aspects (10)
Agile Development Methods	Presentation techniques; Projects.	Group projects with individual written and oral presentations.	- critically examine and reflect on his or her own skills in computer science according to the UN Global Sustainable Development Goals (9)
Project in Full Stack Development	Projects.	Individual written and oral presentation and group project.	Under reconstruction
Development of Mobile Applications	Projects, Imagine workshop	Group projects with individual written and oral presentations.	- discuss the social and ethical issues that may be raised by the use of mobile applications (11) - identify needs for further knowledge and competence for the development of mobile applications (13)
Software Engineering	The project work is in the form of work with company(-ies).	Individual oral presentations and an individual written report.	- demonstrate the ability to make judgements in software projects taking into account relevant scientific, societal and ethical aspects, and demonstrate awareness of ethical aspects of research

			and development work (12)
Bachelor Thesis	An independent project as a specialised study in computer science. (in pairs or individually as determined by the examiner)	Research, written report, oral presentation, written and oral public opposition on another degree project.	- be able to make assessments with regard to relevant scientific, societal and ethical aspects within the field of computer science (6)

4 EXAMPLES OF THE EXAMINATIONS AND PROJECTS FROM SOME COURSES

4.1 Introduction to Computer Science, DA100D

Introduction to Computer Science[2] is the first course that the 1st year Software Development students meet during their education. The course covers a broad knowledge in computer science and equips students with essential academic and scientific skills required for their studies. Additionally, the course provides insight into ethical aspects from a software developer´s perspective and offers a perspective on applied computer science. The students work individually and in groups. Topic of the individual report is “AI in research with a focus on SDG and Ethical Aspects”. Some of the interesting subjects covered in the reports include:

- *Food Waste & AI in SDG efficient production.*
- *AI Implementation in Surgery with an eye on SDGs and ethical considerations.*
- *AI in smart cities. With focus on SDGs and Ethical Aspects.*
- *Role of A.I in Education. Online Teaching and Learning.*
- *The future of humans in an AI-dominated world – with a focus on SDGs and Ethics.*
- *AI´s Fight against world hunger.*
- *Water treatment the environment and the ethical implications.*

It is worth to mention that the report should follow the academic writing style. Students learn how to do literature search, literature study, how to create research questions, how to use the references (tables, figures, literature) and how to write peer review.

4.2 Agile Development Methods, DA116B

The course Agile Development Methods[3] runs as last course in the first year of the programme with purpose to tie together gained knowledge from previous courses, and to develop basic knowledge in carrying out agile software development projects based on the UN Global Sustainable Development Goals.

---

[2] Course syllabus - Introduction to Computer Science - 7,5 credits - DA100D , English | HKR.se

[3] Course syllabus - Agile Development Methods - 7,5 credits - DA116B , English | HKR.se

The students are preparing for the project through a series of lectures and seminars, where they work both individually and in groups to learn about the product engineering and how to align their product with SDG 3.4, which focus on mental health. As a result of the project, a wide range of desktop applications were developed, including:

- Journaling mood applications with resulting graph to bring to doctor's appointments.
- An app designed to help individuals manage personal stress that is based on earth ecology issues.
- Applications that focus on specific groups of people, such as students or the elderly, to promote their health,
- Applications with training programs for physical activities to promote mental health[4].

During the project, students take on different roles such as scrum masters (team leaders), developers, testers, and support staff. They switch between these roles during the four sprints, which culminate in project meetings where progress is evaluated. The students work both individually and in groups, with the aim of developing a final product that addresses the mental health issue they have chosen. At the final presentation, the students give an oral presentation on the development of the final product and submit a written report.

4.3 Software Engineering, DA330A

The course Software Engineering[5] primarily aims to train students in working in large-scaled projects, and has during the years undergone several improvements, such as, outlined in ([9]). The student group is divided up into *main groups* of about 15 students, each such group is furthermore split into sub-groups of about 3 students with the aim of fulfilling one specific technical goal of the system as a whole, according to Fig. 3.

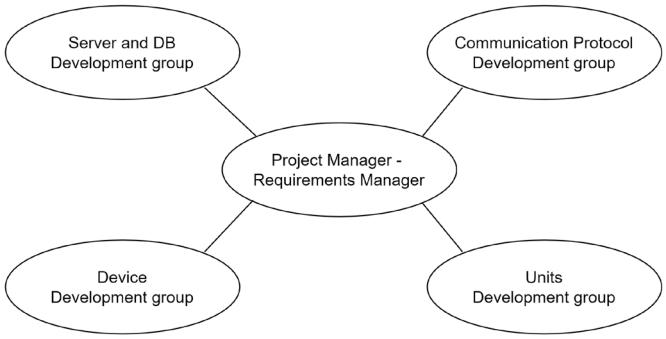

Fig. 3, Student group structure

The main theme of the project under development is to implement a support system for young people with functional disabilities. That approach has its origin in an investigation performed by teachers/researchers of Computer Science at

[4] Myrmidon – appen mot psykisk ohälsa | HKR.se (in Swedish)

[5] Course syllabus - Software Engineering - 15 credits - DA330A , English | HKR.se

Kristianstad University, at a gymnasium for young students with specific needs. The investigation found that the students were dependent on assistance in their living for several banal reasons, such as, turn on lights of lamps, or turn on fans, or pull down blinds to protect against sunshine and warmth in their livings. A consequence of the investigation was an initiation of a Bachelor thesis ([10]) to prototype a smart home-system, where the students should be able to turn on/off lights in their livings.

While that prototype unfortunately did not render further cooperation with the mentioned gymnasium, a consequence was the initiation of a project theme, focusing on Smart Home techniques for young people with functional disabilities. Techniques for supporting such as system is outlined in [11].

The course-students of Software Engineering are aware of that possible stakeholders of the systems are the mentioned gymnasium-students. The course-students should therefore pay respect to the system being supporting the gymnasium-students. As one example, for the course during the spring semester 2023, there is one sub-group that is developing a user interface through an eye-tracker, to support people that are partly paralyzed, and where the eye-tracker is borrowed from an IT-support person at the gymnasium.

The students are furthermore informed about that the system also corresponds to system development to meet SDG 4, on Health and Quality of life. Still, further SDGs that are met by this kind of system are SDG 11 on Sustainable Cities, and SDG 16 on Peace, Justice and Strong Institutions, both addressing the significance in societies being inclusive.

5 RESULTS – SURVEY

37 students participated in the survey. 16 students (43%) were not at all familiar with SDG before joining the University, while 4 students (10%) were a lot familiar with the subject. The overall reaction of applying SDG in CS courses was positive. The answers to the question about the motivation to learn programming through SDG adaptations in CS was very diverse: from 6 (16%) answers “not at all”, through 9 – 12 – 7 in the middle, up to 3 (8%) answers “a lot” (see Fig. 4). The average rating (in scale from 1 to 5) into the integration of SDG in the courses was 77,2%. When asking about the amount of information about SDG covered in particular course, 86% of participants answered: “just enough” for the course “Introduction to Computer Science”, and 89% for the course “Agile Development Methods”. Regarding the relevance of SDG in CS in the future career as software developer, the students were positive giving the average rating of 70,8% (in scale from 1 to 5). Even more positive were they giving the average rating of 81,6% for the question on importance of consideration of ethical and sustainable issues in their work (see Fig. 5). In the open question the students asked about the real-world projects; SDG-focused events such as sustainable tech solutions; collaborations with sustainability organizations. Only one student was very negative about sustainable development, which gives us a thought about some small changes in the first lesson on SDGs and ethical aspects.

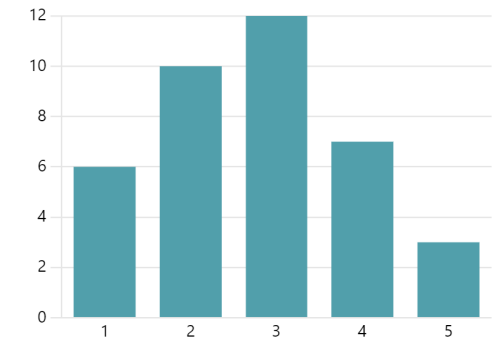

Fig. 4 How much did the SDG subject in CS influence your motivation to learning programming? (1 = not at all, ... 5 = a lot)

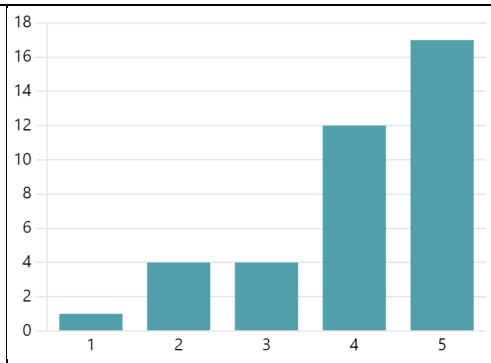

Fig. 5 How important do you think it is for software developers to consider ethical and sustainable issues in their work? (1 = not at all, ... 5 = very important)

6 SUMMARY

Integration of academic and sustainability tracks results, among other things, in high-quality degree theses and more interesting projects with focus on applied computer science. Students write better and can easily connect their reasoning about ethical and sustainable development aspects in the theses and projects. In addition, the students' opinions regarding the implementation of the sustainable development track are quite different, but above all positive. Interesting results were that the students were positive about the importance of the SDG and the consideration of ethical and sustainable issues in their future career as software developers.

Of course, to include sustainability aspects or even academic aspects, something must be skipped in the programme. In our case, we had to exclude some questions/problems that covered pure data science.

The interesting future work would be to ask similar questions to the same students two years after they finished the education.

REFERENCES

[1]	CDIO Initiative Worldwide CDIO Initiative
[2]	Veletanlic, B., Klonowska, K. (2015), Generella kompetenser och forskningsanknytning i utbildningen - en akademisk slinga för dataloger, (in Swedish) Lärarlärdom 2015, s. 163-181, LnuOpen | Lärarlärdom
[3]	Nwankwo, W., Njoku C.C. (2020) Sustainable Development in Developing Societies: The Place of ICT-Driven Computer Education. International Journal of Emerging Technologies in Learning. 15(12):290-297. doi:10.3991/ijet.v15i12.14007
[4]	Gordon, N.A., (2010), Education for sustainable development in Computer Science, ITALICS Innovations in Teaching and Learning in Information and Computer Sciences 9(2), doi:10.11120/ital.2010.09020003 (PDF) Education for sustainable development in Computer Science (researchgate.net)
[5]	Argento, D., Einarson, D., Mårtensson, L., Persson, C., Wendin, K. and Westergren, A. (2020), Integrating sustainability in higher education: a

	Swedish case, International Journal of Sustainability in Higher Education, Vol. 21 No. 6, pp. 1131-1150. https://doi.org/10.1108/IJSHE-10-2019-0292
[6]	Mawonde, A., Togo , M., (2019), Implementation of SDGs at the University of South Africa, International Journal of Sustainability in Higher Education, Vol. 20, Issue 5, 2019 Implementation of SDGs at the University of South Africa | Emerald Insight (hkr.se)
[7]	Fisher, D.H., Bian, Z., Chen, S., (2016) Incorporating Sustainability into Computing Education, IEEE Intelligent Systems, Vol. 31, No. 5, pp. 93 – 96, Sept.-Oct. 2016, doi: 10.1109/MIS.2016.76 IEEE Xplore Full-Text PDF
[8]	Oates, B. J. (2006), Researching information systems and computing. London: Sage Publications
[9]	Einarson, D., Saplacan, D., (2017). Addressing Integrated Learning through Project-Based Courses - Five Years of Improvements. Proceedings of the 13th International CDIO Conference in Calgary, Canada, June 18-22 2017.
[10]	Demant Z., (2012), Interaktivt hus, Bachelor Thesis in Computer Science, Kristianstad University (in Swedish), 2012.
[11]	Einarson, D., Teljega, M., (2020) Smart Home Techniques for Young People with Functional Disabilities, ACHI 2020, The Thirteenth International Conference on Advances in Computer-Human Interactions, Valencia, Spain, 2020.