

From Studying to Learning Computer Science

A study of the first-year experience of computer science education at university

Madeleine Lorås

Norwegian University of Science and Technology
Trondheim, Norway

ABSTRACT

Ensuring that CS students graduate and learn the desired curriculum is important in order to meet the future demands. However, educational institutions have limited room for action as the number of students increases, without additional teaching and structural resources. This research aims to combine knowledge about how CS students' study and the effects of educational design to maximize the pedagogical potential within the room for action at universities today.

CCS CONCEPTS

• **Social and professional topics** → **Computer science education; Information technology education; CS1.**

KEYWORDS

Computer Science Education, First Year Experience, Study Behavior

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1 CONTEXT AND MOTIVATION

The need for computer science (CS) skills and knowledge in society is increasing. With the current student enrollment and graduation rates there will be a gap between supply and demand in the future [14]. Simultaneously, both in Norway and the rest of the world computer science education (CSE) is experiencing an increasing number of students [13]. In other words, the even though the number of CS students is increasing, the demand for CS professionals is not met. This puts a pressure on educational institutions to lower drop-out rates and increase throughput. Research has shown that the first-year experience is essential for retention [3, 15]. Institutions need to develop new education designs in the first year and innovative ways to keep up with high enrollment numbers.

My researched is based at the Norwegian University of Science and Technology (NTNU), which has 11 CS programs with approximately 650 new students every year. These programs are all designed and organized in various ways, which makes NTNU an interesting case. Furthermore, I have decided to focus on the two

largest programs, computer science and computer science engineering, with 150 students each. These students are organized into courses with students from the whole university, which means they are taking a CS1 course with over 2000 students. This causes some challenges to the educational design, especially when it comes to the academic learning environment, sense of belonging and ensuring that the learning outcomes are met. In other words, the need for improvement is big, but the room for action is limited. This research aims to investigate this room for action in an attempt to meet these challenges.

Based on this, the problem statement for my research project is divided into the following three research questions (RQs):

- RQ1: What are different ways the first year of computer science education is designed?
- RQ2: How are students' study behavior effected by the educational design of the first year?
- RQ3: In what ways can the effect of educational design on learning be measured and researched?

2 BACKGROUND

The research questions for this project concern educational design, learning and study behavior in CSE, focusing on the first year. On the topic of educational design and learning the underlying theory used is constructivism. Ben Ari's paper describing constructivism in CSE states that the students create cognitive structures when learning and emphasizes that each individual will perform the construction differently, depending on preexisting knowledge, learning style and personality [1]. In other words, the design of a CS course or a program may to a varying degree enable the students to build such cognitive structures. Correspondingly, the way students' study within this design is important. When investigating learning and study behavior, Biggs' work the study process and Entwistle's work on learning and learning environments are used as theoretical framework. Study behavior has been found to be strongly related to academic performance, and good study behavior is mostly developed early in the student's studies [6]. Study behavior includes both the study habits, skills and strategies of the students, as well as their attitudes and motivation towards studying [2, 9].

Lastly, the importance of the first year experience is based on Tintos research which discusses student departure as several stages; separation (from a known home environment), transition (into a new social and physical structure) and incorporation (into a community and culture) [15] argues that the students' first year experience lays important groundwork, even though students may drop out later in their study.

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Table 1: Overview of research sub-projects and methods

Project	Data and analysis	Research question
Case study of a CS program	In-depth interviews with first year students	RQ2
	Analysis of first year student survey about perceptions and expectations (N=200)	RQ1
Systematic mapping and categorization	Mapping studies of Norwegian and Scandinavian CS programs	RQ1
	Analysis of data from a Norwegian student survey about educational quality (N=1200)	RQ3
Interventions and experiments	Implementation and evaluation of a study day for first year CS students	RQ2
	Quasi-experimental studies on study behavior and educational design	RQ3

3 RESEARCH GOALS

As this research conducted is part of a larger center dedicated to excellence in IT education in Norway, the overall goal of the project is to enhance the learning in NTNU's study programs through increased student engagement and co-reflection among students and staff. My focus is on the first-year experience, where the number of students is high and the distance between academic staff and students large. Firstly, the goal of the research is to increase the knowledge about how first year CSE is designed and implemented. Secondly, the goal is to take on the challenge of designing courses and programs for large student groups within the room for action at institutions today. The room for action is often limited by academic staff, access to appropriate learning areas, scheduling, financial resources and political guidelines.

4 RESEARCH METHODS

The research in this project has a mixed method design with a pragmatic approach. [10]. The project consists of three sub-projects as summarized in Table 1, which build on each other in an iterative manner. The first project, a case study of a CS study program, has an exploratory sequential design, meant to give insight into what challenges the students face and potential areas for improvement [7]. The second project, a systematic mapping of CS study programs in Norway and Scandinavia, has an explanatory sequential design, meant to act as a baseline, as well as help contextualize the research. Lastly, interventions and experiments will be designed and evaluated empirically based on the first two projects.

As seen in Table 1, the data gathered in this project is both qualitative and quantitative. For the qualitative data, a grounded theory approach as described by Corbin and Strauss is used for analysis [5]. For the quantitative data analysis, various statistical methods are used, mainly based on Cohen [4]. Following the mixed method methodology, the results need to be combined, which is done iteratively as described by Creswell [8].

5 CONTRIBUTIONS

As of March 2019, a case study of a first year CS study program has been done, which involved following six students through their first year and a survey of first year students at various programs. The results from these inquiries have shown that students' priorities,

strategies, habits, skills and attitudes are constrained by the educational design, which furthermore may lead to different learning outcomes than desired [11].

Concurrently, the first iteration of a systematic mapping survey of CS programs which was to look at all CS programs in Norway [12]. Based on this work, I am expanding the mapping to investigate selected programs in Nordic countries. The goal of this project is both to increase knowledge about how first year CS education is organized, as well as identify trends and areas for further research.

In the future, the goal is to use both these datasets as a basis for designing quasi-experimental studies for the next two academic years. In addition, some educational interventions are already in place and will be evaluated and analyzed consecutively. Although, this project already has contributed to knowledge about CSE in Norway, a limitation in my research is the generalizability and transferability to an international context.

REFERENCES

- [1] Mordechai Ben-Ari. 2001. Constructivism in Computer Science Education. 20, 1 (2001), 29.
- [2] John Biggs. 1979. Individual differences in study processes and the Quality of Learning Outcomes. 8, 4 (1979), 381–394. <https://doi.org/10.1007/BF01680526>
- [3] John M. Braxton, Jeffrey F. Milem, and Anna Shaw Sullivan. 2000. The Influence of Active Learning on the College Student Departure Process: Toward a Revision of Tinto's Theory. 71, 5 (2000), 569–590. <https://doi.org/10.2307/2649260>
- [4] Jacob Cohen. 1988. *Statistical Power Analysis for the Behavioral Sciences (2nd Edition)*. Routledge.
- [5] Juliet Corbin and Anselm Strauss. 2014. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory (4 ed.)*. SAGE Publications, Inc.
- [6] Marcus Credé and Nathan R. Kuncel. 2008-11-01. Study Habits, Skills, and Attitudes: The Third Pillar Supporting Collegiate Academic Performance. 3, 6 (2008-11-01), 425–453. <https://doi.org/10.1111/j.1745-6924.2008.00089.x>
- [7] John W. Creswell. 2011. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (4 edition ed.)*. Pearson.
- [8] John W. Creswell and Vicki L. Plano Clark. 2017-08-31. *Designing and Conducting Mixed Methods Research*. SAGE Publications.
- [9] Noel J. Entwistle. 1991. Approaches to Learning and Perceptions of the Learning Environment: Introduction to the Special Issue. 22, 3 (1991), 201–4.
- [10] Burke Johnson and Larry Christensen. 2012. *Educational Research: Quantitative, Qualitative, and Mixed Approaches (4 ed.)*. SAGE.
- [11] Madeleine Lorås and Trond Aalberg. 2019. First Year Computer Science Study Behavior: Effects of Educational Design. In *MNT-konferansen*.
- [12] Madeleine Lorås, Guttorm Sindre, and Trond Aalberg. 2018. First year computer science education in Norway. In *Proceedings from the annual NOKOBIT conference 2018*, Vol. 26.
- [13] Engineering National Academies of Sciences. 2017. *Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments*. The National Academies Press. <https://doi.org/10.17226/24926>
- [14] Ministry of Local Government and Modernization. 2014. Dimensjonering av avansert IKT-kompetanse.
- [15] Vincent Tinto. 1988. Stages of Student Departure: Reflections on the Longitudinal Character of Student Leaving. 59, 4 (1988), 438–455.