# A Case Study: The Uppsala Computing Education Research Group (UpCERG)

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## 1 Introduction

We will in this chapter describe the journey of the Uppsala Computing Education Research Group, UpCERG (https://www.it.uu.se/research/group/upcerg), from when it started in the mid-90s till today. This journey began with two teachers wanting to have a better scientific foundation for conducting and developing computing education leading to the situation today when Computing Education Research (CER) is an established research area at Uppsala University with a research program and full professors. There are several ways to tell this story. We will present a roughly chronological outline of how the research group developed in terms of the research areas addressed and the methodologies and theories used. The characterization of research activities in UpCERG is that they are theoretically and methodologically broad, using multiple research approaches and covering many research topics. The chapter will first give a personal view of the development of UpCERG, followed by seeing UpCERG from a theory perspective. The latter part provides a more objective perspective and illustrates how theory has been a crucial part of the establishment of UpCERG. This part draws from a paper presented at the International STEM Education conference iSTEM-Ed [5].

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M. Apiola et al. (eds.), *Past, Present and Future of Computing Education Research*,
https://doi.org/10.1007/978-3-031-25336-2_12

## 2 UpCERG: A Personal View

We start the case study by presenting UpCERG from the point of view of one of its founders, Mats Daniels, partly drawing from chapter two of his Ph.D. thesis [12]. This section provides an inside and personal view of the development of UpCERG. The first part covers the time leading to the Ph.D. defense, followed by the period to the present when UpCERG has a research program and is an established subunit at the department of Information Technology at Uppsala University.

### *2.1 The First 15 Years: A Story of Frustration Fostering Creativity*

There are many ways to start a story, and one is perhaps to observe that I started my Ph.D. studies a little over 40 years ago, on April 9, 1981. The first part of my life as a Ph.D. student related to traditional computer science in the form of using formal methods to describe and analyze communication protocols and computer hardware. It was, as such, not essential for the background of UpCERG, even though teaching and discussing education, both content and form, during this period had a strong influence. This first part of my academic career included earning a licentiate degree in 1985, then working as a lecturer, and spending the year 1989/1990 at La Trobe University in Melbourne, Australia, as a visiting professor.

The part relevant to the formation of UpCERG started when I became director of undergraduate studies in 1991. My work in UpCERG drew on research and experience from a journey that started with being frustrated about the lack of sound scientific foundations for decisions at degree program boards. This led to searching for relevant Computing Education Research to learn from and collaborate with. An essential component on this journey was leading the RUNESTONE project. This project was a stepping stone on forming theories related to Open-Ended Group Projects (OEGP) in computing education based on action research on the development and assessment of professional competencies in the IT in Society course (ITiS).

#### 2.1.1 Frustration

Working in the education field was often frustrating, but at the same time also highly inspiring. This contradiction became even more apparent when I got appointed to some of the boards of studies. Thus, I gained first-hand experience making decisions about the content and running of degree programs. Decisions made in these boards of studies significantly impacted how education was set up, and on numerous occasions, decisions were made without any scholarly evidence.

Typical issues were related to courses, e.g., inclusion or exclusion, their sequence, the needed prerequisites, the size, and even the way they were taught. There were also decisions related to degree program goals, how to follow up on students that achieved a degree or dropped out, and how to recruit students. Many of these issues were decided in rather non-constructive discussions during long meetings.

There was also frustration regarding my shortcomings in my role as an educator, especially after becoming director of studies at the department. An essential part of the latter role was to function as support for other educators and plan the running of the courses the department was responsible for. I felt a need for a scientifically sound foundation for how to act in those roles.

### 2.1.2 Computing Education Research

This frustration led to a search for answers and people who knew more about the issues I had encountered in board meetings and in my roles as educator and director of studies at the department. The time is now the mid-nineties, and we had Vicki Almstrum as a guest lecturer at the department. Through Almstrum, I contacted Nell Dale and her group at the University of Texas at Austin, USA, which was the only group conducting computing education research I could find at that time.

Further searching revealed groups at Open University (Marian Petre), the University of Kent at Canterbury (Sally Fincher) both in the UK, and Monash University (Dianne Hagan) in Australia. We formed a loose alliance called Computer Science Education Research Groups International (CSERGI) to discuss and conduct research building competence in the area. CSERGI ran a set of workshops, one in 1999 dedicated to exploring and defining the research area. This collaboration sparked more focused research in Uppsala, and a new research area was born. Interest in the area grew also with members joining from other divisions, and the recruitment of Arnold Pears from La Trobe University in Australia in 2000. In 2005 Anders Berglund defended the first PhD in the area. The area gathered momentum over the next 5 years, and by 2010, five Ph.D. theses had been defended in this research area at Uppsala University; Berglund [3]; Boustedt [8]; Cajander [9]; Eckerdal [15] and Wiggberg [47].

The research group at the department was first named Uppsala Computer Science Education Research Group but later changed to Uppsala Computing Education Research Group (UpCERG). By 2010 the group had grown to include members from three of the divisions in the Department of Information Technology; Computer Systems, Scientific Computing, and Human-Computer Interaction.

### 2.1.3 International Projects

In the early 2000s there were few, if any, sources from which to apply for research funding for Computing Education Research. However, the national council for the renewal of higher education ("Rådet för högre utbildning") did support large development projects and attendance at conferences in computing education. In 1997 we successfully obtained funding for two three-year projects; Runestone [14] and Espresso [4, 6] My project was the Runestone project, or if speaking Swedish, "Runstenprojektet", in which we established an international student project collaboration between Uppsala University and Grand Valley State University in Michigan, USA.

Runestone was relatively well-financed and is, together with the Expresso project, the start of a real commitment to research in UpCERG. The importance of Runestone as a focus for research is evident from the three Ph.D. theses based on studying aspects of Runestone. These theses were done by (1) Anders Berglund at Uppsala University (Learning computer systems in a distributed project course The what, why, how and where [3]), (2) Mary Last at the University of Texas at Austin, USA (Investigating the Group Development Process in Virtual Student Software Project Teams [25]), and (3) Martha Hause at the UK Open University (Software development performance in remote student teams in international computer science collaboration [21]).

Several aspects of Runestone were interesting, but my particular interest was the issues related to international collaboration. This interest derived partly from an enriching year as an exchange student at Case Western Reserve University in Cleveland, USA, 1979/1980. I wanted to find ways in which more than just a few students could have similar experiences. Runestone provided many opportunities to reflect on how similar experiences could be achieved by adding an international component to our local education setting.

I also started a smaller international collaboration, the NZ project, with Auckland University of Technology, New Zealand, in 1998, after meeting Tony Clear at a conference in Dublin. It was intended to be the first taste of international collaboration for the IT engineering students as a part of their introductory course. This collaboration was prominent in Tony Clear's master thesis 2000 and his Ph.D. thesis [11]. A significant spin-off from my cooperation with Clear was that two students from Uppsala University completed their master's theses [19] in Auckland with Clear as supervisor. These students participated in the NZ project, the Runestone project, and the IT in Society course sequence.

### 2.1.4 Open-Ended Group Projects

Runestone, and project semesters, are examples of courses that were rewarding for students, but there were questions about their educational value. This situation was in the back of my mind when I met two colleagues from the UK, Xristine Faulkner and Ian Newman, at a conference in 2001. It turned out that we had similar frustrations, and we ended up having long discussions about our experiences with this type of course. The more we talked, the more we felt we had a lot in common, both in terms of what we did in our courses units and reactions from students and, especially, education coordinators. We saw potential in how we organized project course units but also obstacles. It soon became clear to us that we more or less told the same story.

What we talked about was exposing the students to a real problem that had no obvious solution and preferably encompassed aspects from many different areas. In short, an open-ended problem. The settings we discussed all included students working in groups and where the problem they addressed was impossible for one individual to deal with alone. Our involvement as educators was limited to offering advice and being there for discussions about the students' progress, with an emphasis on observing the quality of how they worked rather than focusing on how good the solution to the problem turned out to be. Another common denominator was that we saw and accepted that the students could assume very different roles in the projects as long as there was a real collaboration in a group.

We realized that we needed a name for what we discussed and coined the term Open-Ended Group Projects (OEGP). Faulkner later earned a Ph.D. [17] at her university, London South Bank University, UK, mainly based on work with OEGP.

### 2.1.5 The IT in Society Course Unit

My work focused on the IT in Society course unit. This course unit was introduced into the IT engineering degree program as a response to industry feedback collected using questionnaires and meetings before the commencement of the degree program in 1995. This input emphasized that scaffolding the development of teamwork and communication skills was a priority for our industry stakeholders.

Running this course has been a challenge every year since 1998, and it has been a quite inspiring challenge. The development of vocabulary and theories related to open-ended group projects was a vital component in meeting this yearly challenge. The open-ended group project idea suited this course well, but the unique content (e.g., societal aspects) added complexity to setting up a productive learning environment. Such a setting was confusing for the students, since they only had familiarity with highly technical preparation in their other degree courses. Much effort over the years concerns devising appropriate scaffolding to support the students without compromising the underlying ideas behind the open-ended group project concept. My thesis summarizes much of that research.

### 2.1.6 Action Research

The way I worked with developing the IT in Society course evolved in parallel with the development of an educational research framework [13, 36]. This combination of development and research led to a model for scholarly educational development and research, a model that was combined with the action research methodology. The action research cycle fitted the yearly occurrence of the IT in Society course, and the methodology provided a suitable structure for dealing with the research-based development of a complex learning environment.

## 2.2 The Following Decade(+): A Story of Struggles and Consolidation

A fairy tale often ends with “Then they lived happily ever after.”. The “happy ever after” is not the case, and I think it would have been rather dull if there were no challenges or disappointments to deal with.

### 2.2.1 Point of Departure and Continues Work

One thing standing out, looking back at the story, was that most of what I had been working with up until my Ph.D. fell under the professional competence hat. Another reflection was that there had been an integrated process between conducting research-based development and developing a research framework. Professional competence has continued to be a strong interest for me, with working on providing a better theoretical understanding of the concept and especially how to construct educational settings to provide students opportunities to deal with complex real-world issues holistically.

### 2.2.2 Struggles and Consolidation

Interest and devotion can take you far, but it is an uphill struggle without proper funding. Being an interdisciplinary discipline, Computing Education Research (CER) has meant that there are no apparent sources to send grant applications. There is also the dilemma of not having a clear home. For instance, at Uppsala University, there is a faculty of Educational Sciences, but much of the existing Discipline Based Education Research has traditionally been done in the disciplines. UpCERG started at the Department of Computer Systems (from 1999, the Department of Information Technology) without regular research funding. Our work was supported by us receiving development and research grants but also done on a non-funded basis.

Establishing CER as a research area with faculty funding was on my agenda for many years, especially after my dissertation. There were many disappointments, but our results eventually led to establishing CER as one of two areas, the other being AI, that the department pushed for in an internal evaluation exercise at the Faculty of Technology and Natural Sciences in 2018. This push led to the establishment of CER as a new research program, including a stable research budget, in 2020.

Perhaps less of a struggle was to advance my academic status. It had taken 30 years to get my Ph.D., but 2 years later, I became Docent, and in 2017 I was appointed full professor. One year after Arnold Pears became the first full professor in CER at Uppsala University. Another struggle has been the place in the organization. Members of UpCERG belonged to four of the five divisions at the Department of Information Technology. This diversity had its advantages, as members were close to the particular aspect of the computing discipline they were interested in, but it had apparent drawbacks regarding visibility and funding. From 2022 the members of UpCERG are in one unit at one of the divisions.

## 3 UpCERG: Seen Through a Theory Perspective

The previous section gives a rather personal view of the establishment of UpCERG. This story is colored by the narrator but provides one strand of what has formed UpCERG. In this section, we will present the role theory has played in the development of UpCERG. We will briefly discuss theory in CER in general, before getting to how theory became a living part of UpCERG. More in-depth coverage of theory in CER is provided elsewhere in this book, especially in chapter "Theory and Approaches to Computing Education Research".

### *3.1 Why Discussing Theory in CER?*

The term theory is a multifaceted and complex concept. This is a section with a focus on the use of theory in Computing Education Research (CER), and not on theory per se. This quote from Klette in Norwegian Educational Research towards 2020—UTDANNING2020, [24, pp. 3–4], on the role of theory in educational research provides a summary of what theory can mean.

> Simply speaking, theory refers to a particular kind of explanation. Leedy and Ormrod [27, p. 4] state: "A theory is an organized body of concepts and principles intended to explain a particular phenomenon". Thus, theories explain how and why something functions the way it does [23, p.7]. As pointed out by Boss, Doherty, LaRossa, Schumm, and Steinmetz [Boss et al., 2008 [8], p. 20]: "Theorizing is the process of systematically formulating and organizing ideas to understand a particular phenomenon. Thus, a theory is the set of interconnected ideas that emerge from this process". Following McMillan and Schumacher [33], a theory can develop scientific knowledge congruent with the following criteria: first, provide simple explanation about the observed relations regarding their relation to a phenomenon; second, be consistent with an already founded body of knowledge and the observed relations; third, provide a device for verification and revision; and fourth, stimulate further research in areas in need of investigation.

Accepting this discussion as a perspective on what a theory is, we can now focus on the role of theory and its applications in CER. Here we find inspiration in Suppes' pivotal article from 1974 [38] and particularly in section 1, "Why theory?". His first argument is an argument by analogy from the more mature sciences (i.e., mathematics, physics), which can support the need for theory in other sciences, among them educational research. The second argument refers to the reorganization of experience, where Suppes offers the law of inertia, replacing Aristotelian physics as his core example. Another example from CER is to discuss the decline of teaching by transfer as a dominating theory of teaching and learning. Suppes presents the reorganization of experience as his third argument. He argues that what can be found under the surface could be more complex than what can be seen at first sight. Theory offers broader explanations of a phenomenon and thus supports seeing and understanding an underlying complexity. A clear example could be the replacement of the Ptolemaic worldview with the more theoretically sound helio-centric. His final argument is that bare empiricism would be trivial. This shortcoming should be evident for a teacher if unable to refer to theory when explaining something to his or her students.

Certainly, Suppes is not alone in arguing for the usefulness of being theory-aware in educational research, but his arguments are clearly described and consistent over time. Tenenberg and Malmi are editors for two special issues on Theory in computing education research for the journal Transactions on computing education (TOCE). In their editorial [41], they discuss the role of theory in CER. They point out that questions such as: what can be borrowed from other disciplines, how to build theory within CER, how to use theory appropriately, how to combine theory, whether it is necessary to use theory in reporting research or instructional designs, and what we take theory to be, have raised interest in the CER community. Examples are literature surveys, such as [30] on theoretical underpinnings of CER and [28] analyzing ICER papers. Tenenberg and Malmi also point out that journals and conferences often explicitly ask for papers with a clear theoretical foundation. They also share their experiences as editors and program chairs with reviewers finding it challenging to evaluate what is an appropriate use of theory.

That it is a challenge for researchers to select suitable theories is evident in a paper by Szabo and Sheard [39], where they investigate the use of learning theories in CER. They have found that many learning theories are suitable for addressing a given learning phenomenon and that integrating several theories can better explain learning. Similarly, Tedre and Pajunen [40] also observe that there are a plethora of uses of theories in CER, and they focus on the lack of consensus regarding the concept of "theory". They discuss the use and non-use of learning theories from several perspectives, especially the different goals for using theories. They propose a model-based view to avoid the "baggage" associated with the theory concept and that the philosophy of engineering would be more appropriate than the philosophy of (natural) science. Tedre and Pajunen argue that the CER community should work towards its own paradigm, including defining the relationship with theory. They start out their discussion by addressing the maturity of CER, which Malmi et al. [29] also address in their recent work. Their 2022 paper is a survey of papers published at three major CER venues over the time period 2005–2020, investigating the use of domain-specific theories and theoretical constructs in CER. They have observed a progression of domain-specific theory and propose a framework for developing new theoretical constructs in CER.

The CER community has matured, and there is an overall progression related to the use of theory. The latter is evident from the recent papers commented on above. However, it is also apparent that the context of studies still needs to be captured in order to use theory properly in CER papers.

### 3.2 Introduction of Theoretically Robust Research: The First Generation

Uppsala Computing Education Research Group, UpCERG, can trace its first publications to 1996. They were descriptive and mainly presented the teachers' experiences and impressions, possibly with some statistical analyses as a complement, and corresponded often to what Valentine [43] refers to as Marco Polo papers.

The first Ph.D. thesis was produced by Berglund [3], followed by that of Eckerdal [15]. In contrast to the first publications, the theses of Berglund and Eckerdal applied a theoretically well-developed phenomenographic research approach [31, 32] to their studies. Phenomenography is a qualitative research approach that aims to describe how something (called a phenomenon with the terminology from the approach) is understood (or experienced) within a cohort of learners, for example, how university students in IT understand a particular network [2] or the concept of evolution as understood by master students in biology [22] could be the phenomena of interest. The outcome of a phenomenographic study is a set of categories, each of which describes a certain way in which the phenomenon is perceived in the cohort.

Berglund contextualized the results from his phenomenographic studies, using activity theory [16], to describe the learning of CS in an internationally distributed student project. In this way, it became possible to see the learning of particular phenomena within IT, as they were experienced by the students. At the same time, the learning was seen as a part of a broader setting [46]. Eckerdal, inspired by the dualism between and, at the same time, the interaction between theory and practice in students' learning of programming, discussed her phenomenographic outcome space in terms of students' learning of fundamental programming practice. In both these theses, theory was made explicit, both in terms of focus on the CS content and in the use of a robust, qualitative, interpretative theoretical basis. With the work of Berglund and Eckerdal, the importance of grounding research in sound theoretical underpinnings became a part of the "life" and "meaning" of the UpCERG team. This introduction of phenomenography served as a platform and example for how methodologically and theoretical rigorous research could be used to gain insights into computing education.

### 3.3 The Next Generation

Building on these insights, the subsequent theses from the team had clear foci on their research questions and contexts while still writing theoretically well-founded theses. Also, the theoretical and methodological repertoire was extended by selecting research approaches that by the authors deemed relevant for tackling their research questions [13].

In her thesis on students' development of an identity as a computer scientist, Peters theoretical point of departure is the work of Lave and Wenger [26] and studies how participation in a cohort affects and constraints their individual becoming and how the participants shape each other. Boustedt [8] studies the opportunities that can help to overcome the gaps between newly hired and experienced CS professionals by taking a phenomenographic approach. Learning in project courses and the possible gap between students' experiences and teachers' expectations is the core topic of Wiggberg's work [47]. He developed a method focusing on capturing the students' experiences and exploring choices to engage in learning vs pressure to ensure successful implementation outcomes. Alghamdi [1] took a different perspective on capturing teachers' and students' experiences. He studied the experience of teachers and female learners and how to enhance CS education in the context of Saudi Arabia through a set of case studies [42]. Daniels's thesis [12], despite being anchored in case studies as well as action research (see, e.g. [37], still differs from the previously mentioned work. The difference is that the core part of the theoretical development lies in the object of the students' learning, in his case in understanding and developing insights in professional competencies (see [12, section 5.5.1]), and not mainly in the methodology.

This development among the Ph.D. students has developed through rich and lively discussions in the entire UpCERG team on what CER is and how it stands out as different from research in education, sociology, or computer science. This has resulted in several publications discussing the nature of theory and the use of theories in CER [13, 34, 35], and also on the multitude of possible theoretical approaches needed to meet diverse research goals in relation to the culturally situated nature of CS; e.g. [7], on qualitative research in CS education.

### *3.4 Current Development*

The current work of UpCERG focuses on the theoretical achievements of the earlier Ph.D. theses, but also demonstrates a more significant variation in the use of theories and methodologies. An example of this is the work by Kristina von Hausswolff [44]. A recent development is that ethical and moral values are made visible and become essential in the research in a way inspired by that advocated by Clear [10]. Anne Peter's work on sustainability in computing and computing education, as well as Virginia Grande's research on role models, e.g. [18], can here serve as illustrations. Another illustration is the work of Tina Vrieler who uses the computer science capital concept to reflect on instructional design and teaching practice [45]. In her work, she draws on Bourdieu's sociological theory of capital. Still, what unites the current work of UpCERG is its theoretical awareness. The research questions vary between the projects and researchers, but the importance of anchoring research in theory can be found in most of the publications of the last decade.

## 4 Conclusions

This case study on the Uppsala Computing Education Research Group, UpCERG, illustrates the importance of being connected to an international research community and being accepted as a research group in the local context. It also shows how being persistent and having an open mind to how the research field is developing are essential components in establishing a research group in a new area. The example of the journey of one of the researchers, Daniels, gives a personal illustration of the formation of an established research program from a conviction that computing education should rely on a solid theoretical foundation.

The formation of UpCERG has been a joint effort, and the hallmark of the group is the openness to different theoretical approaches and an interest in new ideas. Another guiding light is addressing challenging issues regarding both understanding how computing education can be improved in specific cases and contributing to the grand challenges of society today. An essential common denominator in the work done in UpCERG is to base it on solid theoretical foundation, which is in strong alignment with the general message of this book.

UpCERG has been a part of, and continues to contribute to, the theoretical development in Computing Education Research. The team has a focus on evidence-based learning [20], combined with empirically based research with a rigorous theoretical stance. In summary, as argued by Suppes [38], theory has served to offer analogies, reorganize empirical findings, see the complexity and avoid bare empiricism. Further, the theoretical foundation has provided a language to learn from others and share conclusions. We hope that this case study will provide inspiration and guidance for others to pursue computing education research.

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