Exploring the Past, Present and Future of Computing Education Research: An Introduction

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1 Introduction

While computing has been practiced since ancient times, the record-breaking speed with which computations can be performed today has brought about whole new concerns, challenges and opportunities. Our society has become increasingly dependent on computational devices, and we have generations of people who are actively using and being influenced by digital technologies. Our reliance on technology has brought forth fundamental new questions around how the new power of fast computations can, can not, should, and should not be used. In addition to many benefits and opportunities, new technologies bring forth previously unseen social and ethical dilemmas. Computing skills are required for many jobs, and needed for equal participation in building the information society. The rapid changes brought about by the megatrend of computerisation highlight the importance of computing education, and computing education research (CER).

More than ever, computing education needs constant rethinking and reshaping. It is important to deeply reflect on which computing topics and skills should be taught, to whom, and by what means. There are a number of open questions that need answers. Reliable knowledge is needed about how different computing topics are learned; what is the impact of specific educational interventions or pedagogical

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innovations on students' learning process covering its various aspects, such as attitudes, motivation, studying practices, and learning results; how to contextualise computing education in different parts of the world, or how to best support learning that is based on creating and inventing. Research in computing education (CER) produces scientific knowledge about teaching and learning, beyond individual opinions, and such knowledge is often directly applicable to teaching practice.

CER started as an activity where computing teachers gathered together to share best practices with each other. Over the course of time, CER became a recognised academic discipline with an increasing number of scholars working on the field, new professorial appointments, launch of new research conferences, and expanded focus on new topics such as informal and life-long learning or AI in education [7]. In this book, our aim is to present a new perspective into the evolution of the scientific discipline of CER, by offering a combination of historical overviews, meta-research and reviews, case studies, and scientometric studies to reveal insights into the emergence, growth and present state of the scientific discipline of CER. Meta-analyses and reviews will delve into the evolution of research methods and theory use in publications of CER, from the early times of publishing mainly experience reports to the present day when publication venues require rigorous use of methods and theory. Case studies present the development of the field within specific and prolific communities of practice. Scientometric methods are used in an attempt to map the evolution of the communities and networks, central research themes, shifts in research focus, birth of publication venues, foundational and awarded work, and citation practices.

We hope to offer readers practical guidelines, highlights of topical areas of research, ideas for whom to connect with, where to publish, and what research methods to use. In this book, we wish to paint a picture of influential research, influential researchers, but also that of diversity. In all, this book offers a new perspective to the past, present, and future of CER, which is hopefully of interest to educational practitioners, researchers, students, the general public, and beyond.

1.1 Audience and Related Works

The primary target audience of the book is computing education researchers, from the junior levels to established researchers, and new faculty members entering the field of CER. The book does not have any prerequisites. However, certain chapters will introduce methods for data analysis that might require basic understanding of statistics. The book may also be of interest to teachers and educational practitioners, learning designers, educational managers, policy makers, and other educators or officials. These may include officials working for the ministries of education of governments, industry practitioners, education administrators, policy makers, or any organizations that may be interested in developing and improving their computing education programs.

There are a number of individual research articles, books and handbooks of CER available, from the seminal book *Computer Science Education Research* [3]

in 2004, to more recent ones focusing on computing education in schools [8], and books that cover integration of computing with other disciplines [1], and books that focus more on educational practice than how research is done [6]. The Cambridge Handbook of Computing Education Research [5] covers methodological and theoretical approaches, how to do research, how to teach, common topics of research, common educational technology tools, providing a compilation of key information on methods, topics and general principles in CER [5]. While it also includes some meta-analyses of CER publications, its main focus is elsewhere. This book offers an alternative and complementing perspective to other published books with its unique focus on analysing publication metadata with scientometrics, on large-scale studies, meta-analyses, combined with narratives of development of CER, and case studies of the evolution of practicing research groups and regional research communities.

Different names have been used to denote the field. Some of the most used ones include "computer science education research" [3], "computing education (CEd)" which has been used to refer to teaching practices without a research component, and "computing education research (CEdR)", with a research component added [4]. In this book, our decision is to use the inclusive phrase "computing education research (CER)", which is widely used in the field [5].

2 Organisation of the Book

After the present introduction, the book begins with three chapters that lay out the foundations for understanding the field of CER. First, chapter "What is Computing Education Research (CER)" seeks to describe and define CER: it positions CER as a social science that deals heavily with human participants, and more specifically as an area of discipline-based education research (DBER). The reader is introduced to mainstream discussions and debates of the disciplinary identity of CER, major approaches for classifying CER publications, and mainstream focal areas such as programming education. The chapter higlights central debates, such as frictions caused by CER being a social science, while many CER researchers are trained in computer science.

The foundations of CER are deepened in chapter "Theory and Approaches to Computing Education Research", which introduces the reader to the role of research approach, methodology, and study design in CER. The chapter discusses the role of theory in CER, and points out the pragmatic focus of addressing concrete teaching and learning challenges as paramount in CER, where the questions and nature of useful answers dictate the method and data collection to a greater extent than in general educational research. The chapter also discusses the recent trend of empiricism, and its potential good and bad sides. In all, the chapter lays out a discussion of research quality and rigor, used frameworks and models, and portrays CER as a systematic way of applying scholarly values to understand educational activities in the context of computing.

Chapter “The Evolution of Computing Education Research: A Meta-Analytic Perspective” presents a comprehensive overview of conducted meta-studies of CER. The chapter reflects on CER as a scientific discipline by applying Fensham’s two sets of criteria [2], introducing several mainstream meta-research schemes addressing research topics in CER, research methods and use of theories. Together, chapters “What is Computing Education Research (CER)”, “Theory and Approaches to Computing Education Research” and “The Evolution of Computing Education Research: A Meta-Analytic Perspective” introduce the reader to the foundational characteristics, the grounds of CER.

Chapter “Scientometrics: A Concise Introduction and a Detailed Methodology for Mapping the Scientific Field of Computing Education Research” lays out the methodological approach of this book and introduces the reader to scientometrics as a research methodology. This is followed by a number of chapters that present scientometric findings of various aspects of the field. Chapter “The Hands that Made Computing Education Research: Top Authors, Networks, Collaboration and Newcomers” presents an analysis of author productivity patterns, influential authors, clusters of co-authorship and international collaboration. Chapter “The Venues that Shaped Computing Education Research: Dissemination Under the Lens” presents a scientometric analysis of dissemination practices of CER, revealing top publication outlets, variations in citation rates, and differences in diversity of topics between publication outlets. Chapter “The Evolving Themes of Computing Education Research: Trends, Topic Models, and Emerging Research” focuses on the main topics investigated in CER, showing the major trends of research, such as that on programming education, computational thinking, and K-12 computing education, and analyses how the common research topics are connected with each other. The chapter also brings insights of emerging topics such as machine learning education.

After these scientometric analyses of publication metadata, Chapter “Capturing The Impact and The Chatter around Computing Education Research Beyond Academia in Social Media, Patents, and Blogs” complements the view by turning the focus to social media, news, and blogs. A comprehensive analysis of data shows trendy topics and articles that have sparked public discussion, and attracted attention within the general public. Chapter “A Scientometric Perspective on the Evolution of the SIGCSE Technical Symposium: 1970–2021” continues the scientometric approach by providing an analysis of the publication metadata of the SIGCSE (Special Interest Group in Computer Science Education) Technical Symposium, the oldest and largest venue for presenting CER. The analysis covers research themes, influential authors, and author networks. Chapter “ITiCSE Working Groups as an Engine for Community-Building” continues this trend by focusing on ITiCSE Working Groups, a special form of research collaboration for attendees of ITiCSE (Innovation and Technology in Computer Science Education) conference. This chapter analyses the working group activities and shows how the activity attracts researchers and acts as a pathway for welcoming newcomers into CER.

Chapters “A Case Study: The Uppsala Computing Education Research Group (UpCERG)” and “Future Technology Lab: A Plug-In Campus as an Agent of Change for Computing Education Research in the Global South” provide case-

analyses of two influential CER initiatives: that of the Uppsala Computing Education Research Group (UpCERG), and that of the Future Technology Laboratory (FTLab), a Namibia-Finnish collaborative CER initiative based in Namibia. The UpCERG-group was founded in mid-90's, when two researchers met and agreed to pursue for a better scientific foundation for research of computing education. Chapter "Future Technology Lab: A Plug-In Campus as an Agent of Change for Computing Education Research in the Global South" analyses the trajectory of developing the FTLab-initiative, and gives readers ideas about reforming and contextualising CER in the Global South.

The next series of chapters focus on region-, or country-level analyses. First, chapter "Computing Education Research in Baltic Countries" presents a unique historical retrospective of the development of computing education in the Baltic countries, along with key milestones, achievements, similarities and differences in approaches to CER in Estonia, Latvia and Lithuania. This is followed by analysis of CER in the Global South (chapter "Computing Education Research in the Global South"), in Finland (chapter "Computing Education Research in Finland"), in Australasia (chapter "Computing Education Research in Australasia"), in Israel (chapter "Computer Science Education Research in Israel"), and in the UK and Ireland (chapter "Computing Education Research in the UK & Ireland").

Finally, chapter "Computing Education Research in Schools" provides an analysis of K-12 computing education, which is one of the most researched and rapidly growing domains of CER, including an overview of top categories of research and foundational articles. Chapter "Conceptualizing Approaches to Critical Computing Education: Inquiry, Design, and Reimagination" addresses the critical issues of algorithmic bias, discriminatory practices and techno-solutionism, and discusses potential ways to understand and address them in educational practice.

3 Reflections

We acknowledge that building a comprehensive view of an academic field from its formative years to its current state is not an easy endeavor. Moreover, the view should complement existing analyses and descriptions of the field. The most comprehensive one is the Cambridge Handbook of Computing Education Research [5], which focuses on discussing the research methods, theoretical frameworks, and in-depth presentations of the wide variety of subareas in CER. Our current book presents an alternative view of the field. The scientometric data covers a very large pool of literature, much wider than is available, for example, in the ACM digital library. Scientometrics as a method provides tools for building a big picture of the development of the field covering analyses of authors, their countries of origin, collaboration networks, citation patterns and topics addressed in the research. It thus reveals information which is not visible in topical reviews in such depth. Moreover, it allows identifying and analysing the development of regional and topical subcommunities. Several case study chapters in this book

analyze these subcommunities and provide additional perspectives written by people who are experts in those subcommunities. This allows the reader to understand the differences of the communities and factors behind these differences, which helps building a more holistic understanding on the field. Moreover, it allows to identify best practices in the development of subcommunities, information, which can support the whole field. Overall, this book provides a fresh view of the development and current state of the CER as an academic field.

There is much more that could be done. An obvious track of future activity is to update the scientometric data and analyses after a few years to analyze new developments. Another dimension is to complement the case studies with areas which are not covered in this book, such as CER in other countries or regions in Europe, e.g., Germany, Nordic countries, Southern and Eastern Europe, not to speak about CER in other language areas such as CER in South American countries, India or China. CER in North America is now covered only in the chapter addressing the SIGCSE Symposium, but the field is much richer in this region and the analysis would need much further work. This would naturally require many scholars in those areas to join the effort. Another direction would be to augment the data from other publication databases, as Scopus unfortunately does not include comprehensive data from all years of relevant publication venues. The challenge is that the available meta data is less comprehensive and would require manual updates, a very laborious work. A third direction would be collecting data from various subareas in CER, using more targeted search terms to cover the area more comprehensively. In all, this project is a beginning rather than an end, opening up many new tracks for future research, to be presented in future editions of this book and in current and new publication forums.

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