Breadth of Research in Computer Science Education

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Dr. Manuel A. Pérez Quiñones is a Professor of Software and Information Systems at UNC at Charlotte. His research interests include diversity issues in computing, CS education, and human-computer interaction. He currently serves on the Committee on Women in Science, Engineering and Medicine at the National Academies and served as Program Officer at the National Science Foundation. His efforts to diversify computing have been recognized with an ACM Distinguished Member status (2019); the CRA A. Nico Habermann award (2018); and the Richard A. Tapia Achievement Award (2017). He is originally from San Juan, Puerto Rico.

Dr. Adrienne Decker, University at Buffalo, The State University of New York

Adrienne Decker is a faculty member in the newly formed Department of Engineering Education at the University at Buffalo. She has been studying computing education and teaching for over 15 years, and is interested in broadening participation, evaluating t

Prof. Stephen H Edwards, Virginia Polytechnic Institute and State University

Stephen H. Edwards is a Professor and the Associate Department Head for Undergraduate Studies in the Department of Computer Science at Virginia Tech, where he has been teaching since 1996. He received his B.S. in electrical engineering from Caltech, and M.S. and Ph.D. in computer and information science from The Ohio State University. His research interests include computer science education, software testing, software engineering, and programming languages. He is the project lead for Web-CAT, the most widely used open-source automated grading system in the world. Web-CAT is known for allowing instructors to grade students based on how well they test their own code. In addition, his research group has produced a number of other open-source tools used in classrooms at many other institutions. Currently, he is researching innovative methods for giving feedback to students as they work on assignments to provide a more welcoming experience for students, recognizing the effort they put in and the accomplishments they make as they work on solutions. The goals of his research are to strengthen growth mindset beliefs while encouraging deliberate practice, self-checking, and skill improvement as students work.

Demystifying Computer Science Education Research

Abstract

Computer Science Education Research spans a wide range of topics that shape how computing educators teach, how their students learn, and how the field advances toward equity. However, for some in the engineering education community, the scope of computing education research can be unclear, leaving questions about where it intersects with classroom practice and how to become engaged with a field that overlaps in many ways with engineering education and yet has its own distinct identity. This panel will highlight what computing/computer science education is, where research and classroom practice cross paths, and where there are overlapping issues with engineering education research using concrete examples from computer science education research. Panelists will illustrate: (1) the design of tools that support instruction (2) tools and interventions that promote student learning, including drill-and-practice systems and educational card games; (3) research on how students learn; (4) artifacts that enable effective teaching and assessment; and (5) research advancing broadening participation in computing. By highlighting different, yet interconnected, pieces of computer science education research, this panel aims to clarify the breadth of the field and invite attendees to see where their own work might intersect and contribute. Attendees will leave with a stronger understanding of the role of discipline-based education research in computing and with strategies for applying computer science education research insights in their own educational contexts.

Introduction

Computer Science Education Research spans a wide range of different topics that shape how computing educators teach, how their students learn, and how the field advances toward equity. While computation is a tool used by almost everyone in today's society, including engineers, computing education takes on the scope of thinking about how to teach everyone to use this tool for their own disciplines, while simultaneously working to strengthen how to create future computer scientists that will advance the field of computing. Thus, the scope of computing education research can be unclear, leaving questions about where it intersects with classroom practice and how researchers and practitioners can become engaged with the field.

Some may view the field as only focused on "learning to code", which can be bifurcated into "everyone learning to code" (CS for All) and teaching future

computer scientists and software engineers how to code. Others may view the field as trying to understand how learning works in a computer science context. Another view of the field is that it creates tools and resources for faculty to use when teaching computing. And lastly, there is a view of the field as one that is focused on broadening participation and ensuring access for those who both want to and need to learn about computing for their future careers.

Computer science departments also exist in mainly two forms: those that live at an R1 university (often alongside engineering departments) and those that live at teaching-focused or liberal arts institutions (often without engineering departments). For the departments at large R1 institutions, teaching-focused (teaching-track) faculty have been used for decades. It is often the case that computer science education work is being done by teaching-track faculty and faculty at teaching-focused institutions and therefore is often not seen as *real research* to research-focused computer science departments. Unlike engineering education, there are practically no degree programs in computing/computer science education. There has been a recent uptick of engineering education departments that are including faculty with computing education backgrounds within the department, so it may be the case that computing education will find a home in those departments.

In 2012, the National Academy of Sciences issued a report on Discipline-Based education research [1]. The report states that to prepare a diverse workforce there is a need to support research exploring learning from a specific disciplinary point of view. To improve the undergraduate science and engineering education, this research brings together the expertise of engineers and scientists exploring the learning experiences in their classroom utilizing research methods from learning and cognition. The report calls this collection of various related fields Discipline-Based Education Research. Like Engineering Education, Computing Education Research is yet one more example in this set of technical fields exploring how to improve learning through research in their own discipline's classroom.

Recently the National Science Foundation (NSF) added the Computing Education Research (CER) to the individual programs supported under the Future Computing Research (Future CoRe) solicitation. This new program is a recognition of the importance of CER in the portfolio of programs supported by NSF. The CER program supports "projects that inform our understanding of the effective teaching and learning of computing skills and concepts" as well as supporting various efforts to develop a "robust workforce" for careers in Computer Science

and Engineering. It is worth noting that CER is funded by separate directorates and programs from Engineering Education.

This panel will focus on a deeper exploration of the field of computing education, where research and education cross paths, and how the work integrates with engineering education using concrete examples borrowed from the careers of the four panelists. The panel will provide various examples of CS Education Research that cover various tools, research on how students learn, and explorations on how to make computing more inclusive.

By highlighting different, yet interconnected, pieces of computer science education research, this panel aims to clarify the breadth of the field and invite attendees to see where their own work might overlap. Attendees will leave with a stronger understanding of the role of discipline-based education research in computing and with strategies for applying computer science education research insights in their own educational contexts.

Structure of the Panel

The panel will begin with an overview that explains computing education research and its overlap and distinction from engineering education research. Then, each presenter will use up to 10 minutes to present their work and their experiences doing research in Computer Science Education. The remaining time will be devoted to Q&A with the audience

Panelists

Dr. Stephen E. Edwards

Stephen Edwards is Professor and Associate Department Head for Undergraduate Studies in the Department of Computer Science at Virginia Tech. He has employed multiple equitable grading practices (EGPs) in his own teaching for five years and supported others adopting these techniques at his own institution. He co-organized the SIGCSE Virtual 2024 Working Group that developed the *Playbook of Equitable Grading Practices* [4,5], and is well-known as the project lead for Web-CAT, an open-source automated grading system. He was program co-chair in 2016 and general co-chair in 2017 for the SIGCSE Technical Symposium on Computer Science Education. His contributions to computing education have been recognized with several awards, including the ACM SIGCSE Outstanding Contribution to Computer Science Education in 2021.

Position: Beyond Assessment—Designing Holistically for the Learner Experience. As computer science education research matures, we are moving beyond the era of mere workflow automation and correctness assessment. The next generation of educational tools must pivot from a tool-centric perspective to a learner-centric one, where the primary goal is not just to "grade" student products, but to intentionally design complete learning experiences. By reframing automated feedback as a closed-loop system between the student and the tool, we can focus on fostering targeted changes in student beliefs, behaviors, and self-efficacy. This means deploying platforms that do more than flag syntax errors or give feedback on "correct" answers; it requires tools that encourage a growth mindset and active engagement by considering how the delivery and tone of feedback affect the human on the other side of the screen.

To truly validate the effectiveness of these pedagogical shifts, we must also ensure our tools incorporate systematic, high-fidelity data collection as a core architectural requirement. By capturing detailed interactions and longitudinal student data, researchers and practitioners can move from anecdotal evidence to a rigorous, data-driven understanding of how specific interventions—such as automated nudges or subgoal labeling—impact student persistence and achievement. This evidence-based approach allows us to bridge the gap between classroom practice and disciplinary research, ensuring that our instructional artifacts serve as both a support for current students and a laboratory for discovering the teaching strategies of the future.

Dr. Adrienne Decker

Adrienne Decker is an Associate Professor and Interim Chair in the Department of Engineering Education at the University at Buffalo. She has been studying the teaching and learning of computing for over 20 years. Her work strives to enrich and improve the student experience in computing education, including work in broadening participation. She has secured $3M in funding for her work in computing education and has published over 50 peer reviewed articles in the area. Active in the computing education community, she has served in elected positions on the ACM Special Interest Group on Computer Science Education (SIGCSE) board including chair and treasurer. She was program co-chair in 2014 and general co-chair in 2015 for the SIGCSE Technical Symposium on Computer Science Education and sits on the ACM SIG Governing Board Executive Committee as SGB Representative to ACM Council. She is currently co-chair for the ACM Student Research Competition. She has been actively involved with the Advanced

Placement Computer Science A course since 2011, first serving as a reader, and as part of the development committee for the CSA exam from 2015-2021, serving as higher ed co-chair 2018-2021, was one of the principal authors of the first Course and Exam Description for CSA, and part of the most recent revision efforts to that curriculum.

Position: Dr. Decker's work in computing education has focused in three main areas (1) how students learn and struggle to learn how to program (2) strengthening the rigor of the field and helping to vision for its future and (3) assessment and alternative grading practices. Her work in the introductory programming space has most recently focused on the integration of subgoal labeling in introductory programming courses. Subgoal labels are learning scaffolds that break down problems into pieces small enough for novices to grasp. Leveraging online interactive textbooks that allow for detailed worked examples and practice problems for students to use while learning, this technique has shown to increase persistence for introductory programming students at the university level.

With colleagues at IACE (Institute of Advancing Computing Education), Dr. Decker created a resource center for K-12 computing education research (https://csedresearch.org/) to be used to help elevate the state of the art of conducting and reporting research findings in that space. She was also co-lead of an initiative to bring together thought leaders in the computing education research space to create a vision for the future of computing education. The report *Piecing Together the Next 15 Years of Computing Education* was released in 2024 and suggests ways the discipline can seek to grow and expand in the near future [2, 3]. She is also the lead on a collaborative NSF-funded project to create a community of practice for computer science educators looking to adopt alternative grading practices in their classrooms. Having a long interest in making assessment better, seeking different ways to evaluate students and give them feedback is critical, particularly since the release of LLMs. It is now more important than ever to get students to focus on the learning they are doing, not what they are producing. Different ways of assessing and grading can help us achieve that.

Dr. Miranda Parker

Miranda Parker is an Assistant Professor in the Department of Human-Centered Computing & Education in the College of Computing and Informatics at UNC Charlotte, specializing in computer science education research. Her contributions extend to top-tier computer science education venues, with publications in ACM's

Special Interest Group on Computer Science Education (SIGCSE), International Computing Education Research (ICER), and journals such as ACM Transactions on Computing Education (TOCE) and Computer Science Education. She has served as an Associate Editor for ACM TOCE, Hybrid Experience Chair and Posters/Lightning Talks Chair for ICER, and Doctoral Consortium Chair at Koli Calling. She was recognized as a National Science Foundation Graduate Research Fellow and contributed to the K-12 CS Framework through an internship with code.org.

Position. Dr. Parker's research focuses on revealing and understanding the factors that inhibit equitable computing access and achievement, creating a data-driven perspective of the computing education landscape. To this end, Dr. Parker has an extensive background in developing and validating assessments to measure knowledge and learning gains in computing settings. Spanning from 4th grade students learning sequences and loops to college students in an introductory programming class, these assessments provide valuable insight into what works, or does not work, when teaching computing concepts to students. To address these factors, Dr. Parker emphasizes low-cost and approachable interventions, such as spatial skills training or increased curricular offerings, that facilitate equitable access and achievement in computing. These interventions also include card-based games for learning about computer science education research as a field, allowing for playful interactions and iterations on research questions and between researchers of all levels.

Dr. Manuel A. Pérez-Quiñones

Dr. Manuel A. Pérez-Quiñones is a Professor in the the Department of Human-Centered Computing & Education in the College of Computing and Informatics at UNC Charlotte. His research interests include diversity issues in computing, computing education, and human-computer interaction. He is an elected member of the Board of Directors for the Computing Research Association, a former Program Officer at the National Science Foundation, and a former member of the Committee on Women in Science, Engineering and Medicine at the National Academies. He served in the ACM Special Interest Group on Computer Science Education (SIGCSE) board and was program co-chair in 2018 and general co-chair in 2019 for the SIGCSE Technical Symposium on Computer Science Education. His contributions to computing education have been recognized with the ACM SIGCSE Distinguished Service to Computing Education (2025); ACM Distinguished Member status (2019); the CRA A. Nico Habermann award (2018); and the Richard A. Tapia Achievement Award (2017).

Position. Dr. Pérez-Quiñones has been part of several groups that have developed numerous tools for CS Education. Some of his early work included the development of full development environments for Ada (e.g., SmallAda, GWU Ada/Ed) providing Ada language with features tailored for educational uses. He later created MinimUML, a simplified UML diagramming tool for use in the early computer science curriculum. Dr. Pérez-Quiñones has also done research exploring the use of paper prototyping with middle school girls as a way to explore underrepresentation in computing, common misconceptions in novice programmers, the use of peer review in intro courses, as well as the effects of individual differences on CS2 course performance.

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