Exploring Pathways to Developing Self-Efficacy in New Computer Science Teachers

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Abstract

Multiple efforts at Mississippi State University (MSU) are working to support the Mississippi Department of Education (MDE) and White House initiatives of providing access to computer science learning for all K12 students. In the summer of 2016, MDE, in partnership with the Research and Curriculum Unit at MSU, conducted professional development workshops in preparation for the rollout of computer science courses in 68 self-selected public schools. In addition, MSU piloted a teacher institute with a goal of enabling teachers from a variety of disciplines to integrate computing and cybersecurity concepts into the classroom. Although both of these professional development programs offered support for the goal of providing computer science learning to all K12 students, the approaches were distinctly different. A summary of both experiences and related observations will be shared, with recommendations for best practices in bringing computer science to K12 classrooms in the state of Mississippi.

Keywords

Computer science education, self-efficacy

Introduction

While the number of jobs in computing professions continues to grow, the number of college students in the United States who choose the majors needed for these professions does not meet the demand.[1] Computer scientists in the southern United States, which includes the state of Mississippi, are underrepresented compared to the rest of the nation.[2] Mississippi has one of the lowest concentrations of computer and mathematical occupations in the country and has the lowest range for annual mean wage for computer and mathematical occupations.[3]

To address these issues in Mississippi, the Mississippi Department of Education (MDE), in collaboration with Mississippi State University's (MSU) Research and Curriculum Unit (RCU) began a 3-year Computer Science (CS) pilot in 2016 with 38 school districts participating. Fifty-three high schools are offering the NSF funded Exploring Computer Science (ECS) Curriculum and 115 elementary schools are incorporating Code.Org and Common Sense Media Digital Citizenship lessons into their classes. MSU's Computer Science and Engineering (CSE) department has been providing computing outreach experiences since 2011 including summer camps and undergraduate research experiences with a focus on broadening participation among underrepresented groups.[4] Out of a total of 113 scholarships awarded, twenty-seven women and twenty-one students identifying as African American have participated in the CyberCorps Scholarship for Service (SFS) at MSU (NSF # DUE-1241722). In 2016, the first teacher professional development summer workshop was offered by CSE in collaboration with the College of Education.

Computer science influences a broad range of disciplines including communications and media, medical, business, and other sciences.[4] Recognizing that computing is used to design technical solutions to problems in a variety of domains, MSU has sought to offer an interdisciplinary approach to building computer literacy among students in Mississippi through summer outreach experiences.[6] Teachers and students are often unaware of the multi-disciplinary impact of computing and those in rural areas have less access to extracurricular activities that encourage computing and have fewer role models in the field.[5] As a result, it is less likely that learners in these geographical areas, particularly females and African Americans, are able to visualize themselves pursuing a computing degree or working in a computing career.[7] Teachers can also unintentionally steer students away from CS if they unconsciously do not associate a certain race or gender with the occupation.

Currently, Mississippi does not have a specific licensure requirement for teaching computer science courses; rather there are several alternative pathways to the classroom that do not necessarily include substantial coursework in CS. In fact, the current route into instructional technology is business education-based. Therefore, part of establishing effective CS programs in Mississippi will be to understand both who is teaching and how these teachers arrive in the classroom.

Self-Efficacy

This work was driven by the researchers' conceptual understanding of self-efficacy. The idea of self-efficacy is a key component in both teacher practice and student achievement.[8, 9] Self-efficacy, the belief in your ability to be able to teach students in a given course is directly related to the teachers confidence in their understanding of both the content of the course and their pedagogical ability to convey the content in meaningful ways to the students. Bandura in his definition of self-efficacy emphasized that personal beliefs and actions lead to attainment.[11] Teachers that are provided with opportunities to reflect on their own practice and examine way to improve through professional development or self-study increase their self-efficacy in their understanding of content and their ability to teach.[12,13] Self-efficacy studies and studies on quality professional development indicate that teachers who understand what they know are also willing to seek knowledge to fill in their own gaps of understanding.[14,15]

Student achievement is impacted by teacher's knowledge of content.[16] Teachers who are able to present clear, meaningful lessons to students are able to positively affect student understanding. Self-efficacy research indicated that students of confident teachers are more confident in their own ability to learn which motivates them to engage in the learning process.[17, 10] Quality professional development opportunities that integrate teacher content knowledge with meaningful reflection and examination of best practices lead to an increase in teacher self-efficacy.

The Role of the Teacher in Student Self-Efficacy

Studies have shown that a teacher's unconscious bias can negatively impact a student's confidence in math and science. Teachers are often misguided by a common stereo-type that male students are better at math and science subjects than girls and may offer the boys more opportunities in class and allow them to dominate discussions.[18] A study of Israeli students showed that a classroom teacher graded boys higher on a math exam than outside graders who did not know the gender of the student. This unconscious bias carries over into the work force as well.[19] Corinne Moss-Racusin, a social psychologist at Skidmore College performed an experiment where she and her colleagues created two fictitious resumes, identical in every way except the name of the candidate: one was John and the other was Jennifer. The resume was then sent for review to over one hundred scientists across the country for a lab manager position. Results showed that Jennifer was considered less competent and offered a lower salary (13% less) than John. Even the female scientists favored John over Jennifer.[20]

The ECS rollout

MDE launched the Exploring Computer Science (ECS) program in self-selected schools across the state in fall 2016. The curriculum development was funded by a National Science Foundation Broadening Participation in Computing grant (NSF grant #1241284). The implementation includes two one-week summer trainings and eight one-day meetings over two school years. MDE contracted with RCU to facilitate the ECS rollout. Hollis represented RCU at the training throughout the summer.

Sixty-seven Mississippi high school teachers, mostly Caucasian and female as reflected in Figure 1, were trained in the ECS curriculum in the summer of 2016. The ECS project seeks to provide a survey of computer science including a focus on critical thinking and problem solving. Also included in the ECS professional development is content that is intended to communicate issues about a lack of diversity in the computer science pipeline. The teachers who participated in the week of professional development were not aware of the content of the training before attending. Most were told that they would be teaching computer science in the upcoming fall semester and must attend training beforehand.

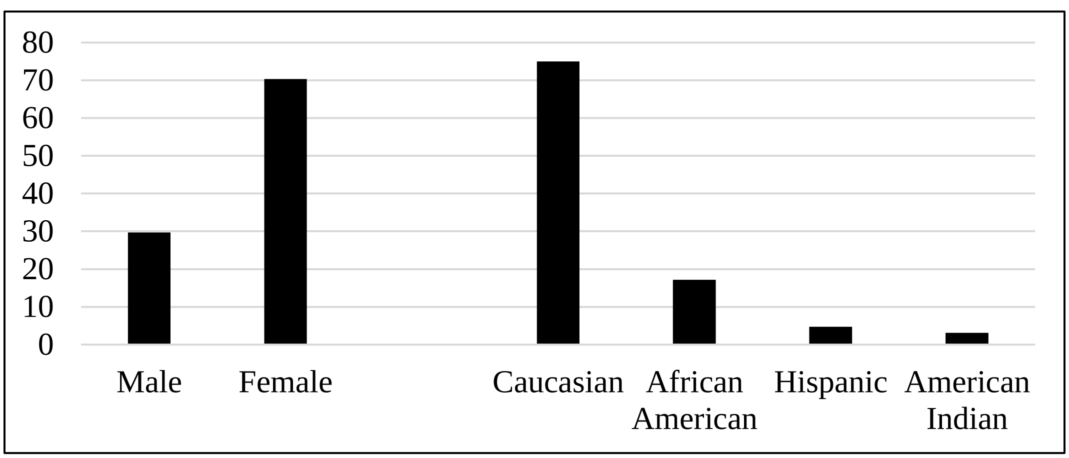

Figure 1. ECS PD Participant Demographics

An external facilitator was used for the ECS professional development. Metaphors were used to introduce the concept of self-efficacy issues among underrepresented groups in computing study and careers. Hollis perceived much resistance among teachers who believed they did not need any training on equity or recognizing bias and that some of the participants did not believe that those issues were present in their schools districts. However, comments throughout the training indicated that many did view boys as better analytical thinkers than girls. A quote from a recent Olympic medalist summarizes well the self-efficacy message that the participants overall did appear to recognize:

> Simone Manuel, the first African American female swimmer at an Olympic Games, stated "I would like there to be a day where there are more of us and it's not 'Simone, the black swimmer,'" she said, "because the title 'black swimmer' makes it seem like I'm not supposed to be able to win a gold medal or I'm not supposed to be able to break records and that's not true because I work just as hard as anybody else. I want to win just like everybody else."[21]

RCU observations of ECS professional development indicate that many of the teachers believed they needed additional content training and exposure. Follow-up observations by RCU in the ECS classrooms revealed teachers giving superficial coverage to content that they were less confident with. RCU observers also reported an apparent uneasiness with allowing students to have a productive struggle in their quest for a solution, seeking instead to give students the answer. This indicates a need for additional training on CS methodologies and pedagogies for the classroom.

MSU's Interdisciplinary Teacher Professional Development

The approach to communicating the self-efficacy gap in computing was different in the teacher training that was hosted through the MSU CSE department. Through support from the National Security Agency's GenCyber Program, MSU hosted an interdisciplinary group of secondary teachers for the 2016 Bulldog Bytes Teacher Workshop. The workshop was structured to include components of effective professional development including: (1) fostering collaboration among STEM disciplines, (2) identifying and developing curricular materials, (3) purposefully integrating pedagogical content knowledge, and (4) recognizing and promoting technology education as a part of K-12 education.[22] Further, the recommendations of Avery and Reeve (2013) were incorporated. These recommendations include providing a professional development setting that gives teachers a sense of ownership and value, providing exemplar design challenges through projects and problem solving, fostering the evaluation of student work, considering standards-based pressures on STEM learning, and integrating STEM concepts into familiar curricular materials.[23]

The 2016 Bulldog Bytes Teacher Workshop included a weeklong experience structured as a combination of computer science content instruction, pedagogical instruction, and classroom planning. The nine participating teachers represented a variety of disciplines including mathematics, physics, information computer technology, and engineering. Each teacher received a stipend, continuing education units, five Sphero robots, and a Kindle Fire tablet.

The computer science portion of the workshop consisted of time that was embedded in a student GenCyber camp; however, the teachers functioned as "additional students" because none had extensive training in the concepts taught. Lesson topics covered were cyber security concepts, digital forensics, data security, cryptography, programming, safe passwords, and reverse engineering. Lessons included explicit connections to the GenCyber First Principles: process isolation, information hiding, domain separation, least privilege, minimization, abstraction, layering, resource encapsulation, modularity, and simplicity of design.

The pedagogical component of the workshop consisted of teachers working collaboratively with a lead instructor to discuss methods of teaching. Concepts explored during this aspect of the camp included questioning strategies, such as integrating reversibility, flexibility, and generalization questions in teachers' respective disciplines. Teachers also explored grouping and instructional strategies to actively engage learners. Through a professional learning model, teacher participants engaged in interdisciplinary planning, with an explicit focus on incorporating cyber topics in their classrooms, which ranged from mathematics to engineering to physics with students from sixth to twelfth grade.

The final day of the workshop provided opportunities for teacher participants to refine lessons to use in their classrooms during the upcoming school year. These lessons merged the two prior components (cyber and programming concepts) and appropriate instructional strategies. Lessons were shared on a cloud drive to encourage collaboration and continuation beyond the workshop.

Feedback indicated that seven of the nine participating teachers planned to integrate computing concepts in their classroom as a result of their experience in the workshop. Willingness to integrate new content is related to the teachers' self-efficacy for teaching the content. The other two participants planned to adapt existing cyber-related lessons based on their experiences and new classroom resources. Teachers noted areas of the workshop which were of particular relevance to their classroom instruction included: (1) the vulnerability of society due to dependence on computing for everyday life, (2) cross-curricular project challenges, such as creating reverse-engineering projects in physics or engineering courses, (3) internet safety for students, and (4) consideration of the broad range of computing careers and pathways.

Summary

Initial reactions to the ECS professional development experience has shown us that we need to evaluate the usefulness of both models. It is clear that content knowledge for teachers is critical. The model used in the interdisciplinary teacher professional development emphasized the content knowledge while helping teachers systematically integrate this new knowledge into their lesson plans. This approach seems promising for helping teachers gain both content and pedagogical knowledge to become confident, effective teachers of computing. Finding ways to address teacher concerns about lack of knowledge in computer science is also critical in building self-efficacy. Intertwined in this development is helping the teachers discover their own bias and recognize bias in school administration particularly as it relates to computer science and its importance in the school day. For many students the classroom teacher may be the only source of positive encouragement toward computer science they receive. As we make progress in understanding teachers' knowledge, dispositions and self-efficacy towards computer science we can help our teachers consciously engage *all* students in math and science inquiry and discussion.

Our next steps include expanding these efforts to larger groups of teachers and students, as well as bridging the gap between engineering and education at a critical juncture, teacher preparation. Work is currently underway to bring computer science embedded experiences to pre-service mathematics and science education undergraduates, offering opportunities for teachers to integrate these concepts from their first days in the classroom and creating school leaders and mentors in this domain.

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