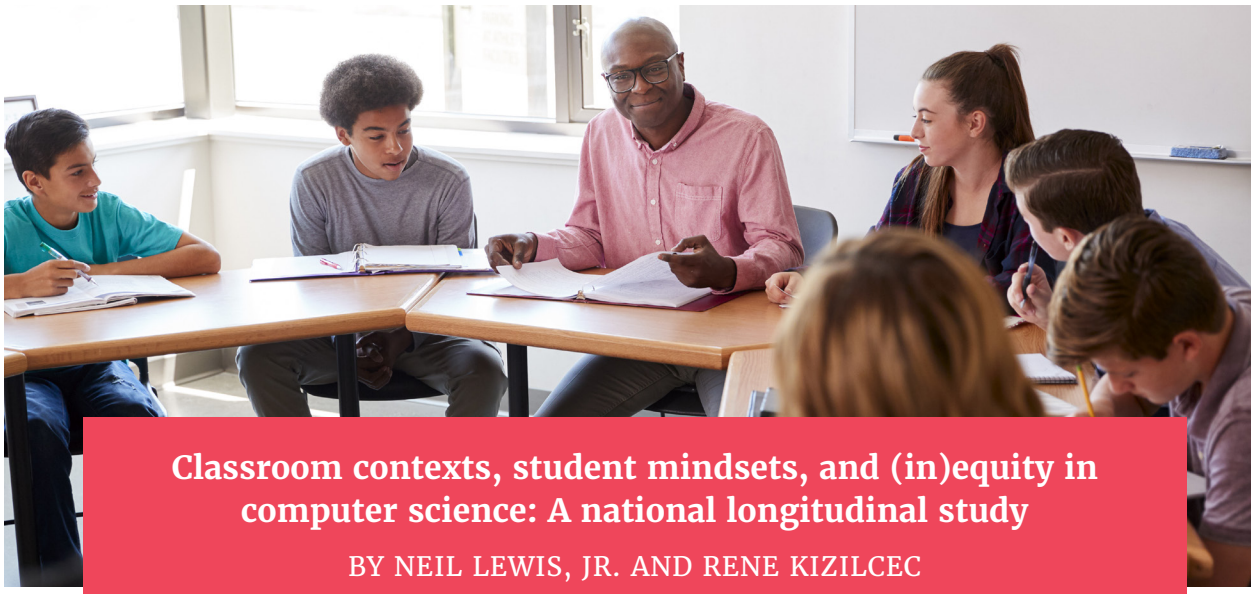

Classroom contexts, student mindsets, and (in)equity in computer science: A national longitudinal study

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RESEARCH SNAPSHOT | OCTOBER 2021

Computer science has long struggled, and continues to struggle, to train women and racially minoritized students. This is in part due to the structure of computer science learning environments and the messages they communicate to marginalized students about whether or not they belong in the field.

In this study we examined how both structural features of learning environments and students' mindsets affect their engagement and performance in computer science early in the academic journey – in high school. We partnered with Code.org to conduct a longitudinal study to examine how learning dynamics unfold over time for different groups of students.

Study Design

We conducted this study in collaboration with Code.org during the 2017-2018 school year. Code.org is a non-profit organization dedicated to increasing computer science access in schools, with a particular focus on increasing engagement among women and racially minoritized students.

Code.org offers a course on "CS Principles" which introduces students to the foundational concepts of computer science and challenges them to explore how computing and technology can impact the world. The course is endorsed by the College Board for Advanced Placement (AP) Computer Science Principles, and is available for schools and teachers to use at no cost. We worked with Code.org to embed surveys into their curriculum throughout the year to measure how students'

Key Findings

- Female students and racially minoritized students began Advanced Placement Computer Science with lower expectations of classroom belonging and were less sure that computer science was relevant to their future. Female students were more worried about their lack of experience in computer science, and were more worried that their gender would negatively influence how others perceived their capabilities, than were their male peers. Racially minoritized students began the course more worried about their mathematics experience than their white and Asian peers. These mindsets and concerns mattered for student engagement.
- Performance early in the course affected students' mindsets and performance later in the course. Students who performed well early on became more convinced that computer science was relevant to their future, and productive changes in mindsets increased future engagement and performance later in the course.

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student experience RESEARCH NETWORK

Student Experience Research Network (SERN), formerly known as Mindset Scholars Network, envisions an education system in which every student experiences respect as a valued person and thinker, so that they can learn and thrive. To this end, SERN connects people and ideas across research, practice, and policy to advance scientific knowledge and inform decision-making by education system and institution leaders.

Sample

Participants in this study were more than 106,000 high school students from across the United States who were enrolled in the Advanced Placement Computer Science course facilitated by the non-profit organization Code.org during the 2017-2018 school year. The student population was 31% female (68% male) and 58% white or Asian (42% identified with minoritized races and ethnicities). This course was deployed in over 11,000 classrooms from over 3,000 schools via over 6,000 teachers.

mindsets changed while taking the course. This allowed us to examine the relationships between student demographics, mindsets, and course outcomes, while also examining the effects of structural features of the learning environment.

The computer science course we studied consisted of five learning units. Students' mindsets were measured at the start of the course (pre-survey), around the middle of the course (mid-survey), and at the end of the course (post-survey). Embedding the surveys on this timeline allowed us to examine how the mindsets students came to the class with affected their early learning experiences, then to examine how experiences in the classroom changed students' mindsets, engagement, and performance in the course.

The surveys measured five aspects of students' psychological experience: their sense of belonging in the classroom, the extent to which they were concerned about being judged in line with negative stereotypes about their gender and racial groups, the extent to which they saw computer science as relevant to their future goals, their perceptions and worries about their experiences with mathematics and computer science, and their beliefs about whether intellectual abilities can change. In our analysis, we also included demographic information for students (age, gender, and race and ethnicity) and teachers (gender and race and ethnicity), as well as features of the classroom (class size, proportion of female students, proportion of racially minoritized students) and school (school size; whether the school was in an urban, suburban, town, or rural location; proportion of racially minoritized students, proportion of students eligible for free lunch).

Key Findings

Female students and racially minoritized students began AP Computer Science with lower expectations of classroom belonging and were less sure that computer science was relevant to their future. Female students were more worried about their lack of experience in computer science, and were more worried that their gender would negatively influence how others perceived their capabilities, than were their male peers. Racially minoritized students began the course more worried about their mathematics experience than their white and Asian peers. These mindsets and concerns mattered for student engagement.

The research finds that female and racially minoritized students entered AP Computer Science courses with negative mindsets about their belonging and preparation in the course, how it relates to their life, and how their peers view them. Many of these mindsets impacted subsequent engagement and performance in the course: students who viewed the course as more relevant for their future, those who initially worried about their lack of prior computer science experience, and those who believed that some are better at learning and doing computer science than others were more engaged with the course material. However, students who worried about their mathematics competency and those who were worried about others perceiving their computer science ability being tied to "gender, skin color, or background" were less engaged. Overall, racially minoritized students studied fewer lessons on the online learning platform than their white and Asian peers.

Performance early in the course affected students' mindsets and performance later in the course. Students who performed well early on became more convinced that computer science was relevant to their future, and productive changes in mindsets increased future engagement and performance later in the course.

Students generally attend to signals of academic performance to adjust their mindsets and regulate their effort. For this reason, we examined whether students' grades early in the course would influence their mindsets, and found that receiving high scores early on made students feel that the course content was more personally relevant, as measured by their agreement with statements like "computer science is important for my future" and "I expect that I will use computer science as part of my job." Increased relevance also increased their subsequent engagement.

Insights & Future Directions

The decision to pursue a professional and academic career in computing can be influenced by early experiences and mindsets in K-12 learning environments. We find that computer science courses can make computing feel personally relevant to students if they do well early on. This can in turn positively influence students' long-term engagement and performance, and that this is particularly true for students from minoritized racial and ethnic backgrounds.

Our findings offer guidance to policymakers and behavioral scientists who are working to improve the underrepresentation of women and racially minoritized individuals in computing fields: ensuring students receive positive reinforcement early on can foster personal relevance and support achievement. Elementary, middle, and high school administrators and teachers have an opportunity to shape students' mindsets and early academic experiences (e.g., their first assessment scores) that eventually influence their decision to sign up for AP Computer Science and persist in the course, especially for female and racially minoritized students.

While several mindsets are predictive of student outcomes, the one that stands out as being malleable and having longer-term effects is students' sense of personal relevance to the course materials. This suggests an opportunity for early intervention to help students realize the potential utility value of academic training in computing. This makes a strong case for future research that tests a utility-value or similar intervention at the start of AP Computer Science courses to nudge students to consider pursuing an academic career in computing. It also suggests to policymakers and educators that connecting students to professionals in the field and incorporating review of potential career paths into curricula could strengthen interest in computing among female and racially minoritized students in particular.