Chapter 4
Educational Robotics for Creating Effective Computer Science Learning for All

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ABSTRACT

President Obama's initiative, "computer science for all," has been a rallying slogan for promoting computer science in K-12 education. Although the participation of people of color in computer science (CS) has increased in the past several years, it is still drastically low and does not reflect the real picture of our society. This chapter explores how educational robotics as a learning tool can inspire underrepresented minorities including females and students of color to become interested in CS. Supported by Papert's constructionism theory, educational robotics effectively facilitates students' learning of various concepts in CS and STEM. Educational robotics is a learning tool which inspires students' interest in learning. It provides a learning environment that promotes students' learning of various CS concepts and computational thinking skills. Although robots naturally spark students' interests, to make it most effective, teachers are required effortfully to create learning opportunities that are authentic and meaningful for individual students.

INTRODUCTION

President Obama ignited and accelerated the movement to promote coding among K-12 students during his final State of the Union Address in 2016, sharing that helping students learn to code was one of his goals for years to come (National Public Radio, 2016). Since then the coding movement has gained momentum (Richtel, 2014). The Hour of Code (https://hourofcode.com) initiated a worldwide effort to promote coding and celebrate computer science by offering a one-hour introduction to computer science activity in 2013 during the Computer Science Education Week. This has become an annual worldwide event involving pre-readers to high school students and beyond. The Hour of Code aims to show that

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everyone can learn the coding basics and hopes to broaden participation in the field of computer science. The Hour of Code's one-hour tutorials are in over 45 languages. They have served 1,000,706,674 students since 2013, with participation from over 180 countries. It is reported that over 140,000 events were registered in 2019.

The report produced by the Code.org Advocacy Coalition and the Computer Science Teachers Association (CSTA) indicated, since 2013, when only 14 states and Washington, D.C. had at least a policy to make computer science a fundamental part of their state's education, the number has jumped to 44 states by 2018 (Code.org Advocacy Coalition and Computer Science Teachers Association, 2018). It also reported that since 2017, thirty-three states have passed new laws and regulations to promote computer science education in their state. In 2018, twenty-two states had adopted academic standards laying out the computer science skills and concepts required for their students to learn, and eleven more states were developing standards. Fifteen states required all high schools to offer computer science. Moreover, some states require schools to offer computer science instructions before students reach high school, including Florida, Indiana, New Hampshire, and Wyoming. Thirty-nine states included computer science as one of the core high school requirements for graduation.

Although the prospect of computer science education in the U.S. seems promising from the data shared above, the report also highlighted that their preliminary findings from the twenty-four states who completed the study indicates that only 35% of high schools in the U.S. teach computer science. In addition, it emphasizes that high schools with higher percentages of Black and Hispanic (underrepresented minority - URM) students (35% for high schools serving 50 – 75% URM students; 27% of high schools serving 75-100% URM students vs. 41% for high schools serving 0-15% of URM students) and students receiving free or reduced lunch are less likely to offer computer science courses. Students in rural areas also have less access to computer science education (29% of high schools in rural or town communities).

The situation for elementary and middle schools is much worse than for that of high schools. As mentioned, some states have laid out a requirement for their schools to offer computer science learning experience before students move to high school. In 2014, the Chicago public school system became the first school district to offer computer science education from elementary school to high school (Chicago Public Schools, 2014). The five-year *Computer Science for All* plan could support an initial group of twenty-five elementary schools to incorporate computer science lessons into math and science lessons. In the following year, the San Francisco Public School District implemented its own pre-K-12 computer science program (San Francisco Public Schools, 2015). Since 2018, Florida requires all high school and middle schools to offer computer science or provide students access to computer science instructions. Nevada adopted K-12 computer science standards and requires high schools to offer a computer science course, and elementary schools to provide computer science instructions before 6th grade. They also emphasize that schools must address the need to increase underrepresented minority's participation including girls, students with disabilities, and students of color. Indiana requires all schools, from elementary to high schools, to offer computer science by 2021-2022 academic year. Since 2018, New Hampshire requires all schools in the state to offer computer science instructions. Wyoming requires all K-12 schools to include instructions in computer science and computational thinking by 2022-2023 academic year. Gradually, it is expected that more states will follow the movement in the coming years.

However, a question still remains – "How can we best teach such abstract computer science and computational thinking concepts while reaching *all* students?" One could argue that teaching programming to 3rd grade or younger students might not be effective (Kishida 2016). Kishida refers to Piaget's theory of cognitive development to support his argument. Piaget's theory suggests that children gain