Chapter 9
The Impact of Educational Robotics on Student STEM Learning, Attitudes, and Workplace Skills

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ABSTRACT

This chapter discusses findings from a National Science Foundation (NSF) project funded by the Innovative Technologies Experiences for Student and Teachers (ITEST) program. The project has an ongoing research agenda focusing on the impact of robotics summer camps and competitions targeted at middle school youth. The research focused on the impact of the interventions on youth a) learning of computer programming, mathematics, and engineering concepts, b) science, technology, engineering, and math (STEM) attitudes, c) workplace skills, and d) STEM career interest. Results show that robotics camps and competitions appear to be viable strategies to increase student STEM learning, robotics self-efficacy, and problem solving skills.

INTRODUCTION

The United States economy is highly dependent upon advanced technology. Maintaining this technological infrastructure and U.S. competitiveness hinges upon K-12 mathematics and science education. However, the alarming state of science, technology, engineering, and mathematics (STEM) education in the U.S. is most overtly evidenced when standardized test scores of American students are compared to those of their international peers: by age 15 U.S. students perform relatively poor in mathematics and drop below the global average in science literacy (Lemke et al., 2004). A report by Education Week (2008) confirmed that these trends are continuing, with U.S. stu-

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dents scoring in about the middle of international mathematics and science comparisons. These low scores have renewed calls for new approaches to STEM instruction and uses of technology. When asked to identify 10 actions that federal policy-makers could take in response to this crisis, the National Research Council's first suggestion in *Rising Above the Gathering Storm* (2007) was to "increase America's talent pool by vastly improving K-12 science and mathematics education"

One promising approach to support school learning is out-of-school programs, which are gaining popularity for enhancing the overall learning environment (Bell, Lewenstein, Shouse, & Feder, 2009; Bredin et al., 2010; Falk, Dierking, & Foutz, 2007; Hussar, Schwartz, Boiselle, Noam, 2008). After-school and summer hours are being used for extended investigations, hands-on activities, and field trips that are difficult to pursue within the confines of a school bell schedule and curricular demands. Such informal learning environments can allow for additional experimentation and exploration in a more relaxed and experiential setting, free from the need to prepare for a "test". Educators and parents are increasingly looking to such educational opportunities to promote learning and to contribute to youth academic success and motivation.

This chapter examines how an innovative robotics program titled *Geospatial and Robotic Technologies for the 21st Century* (GEAR-Tech-21)--designed for delivery through informal learning environments and delivered in a variety of formats such as summer camps and robotics competitions--supports middle school youth STEM learning and motivation. The objective of the chapter is to discuss findings from this NSF project funded in the Innovative Technology Experiences for Students and Teachers (ITEST) program. While focusing on research results, the discussion provides information on the project's robotics programs, curriculum, research designs, instrumentation, and procedures.

EMPIRICAL RESEARCH BASE FOR EDUCATIONAL ROBOTICS

Robots have been recognized as having the potential to transform and enhance the learning process in education (Chambers & Carbonaro, 2003; Jonassen, 2000). Through hands-on experimentation such technologies can help students translate abstract mathematics and science concepts into concrete real-world applications. Research supports the use of educational robotics to increase academic achievement in specific STEM concept areas closely aligned with formal education topics and coursework (Barker & Ansorge, 2007; Nourbakhsh et al., 2005; Rogers & Portsmore, 2004; Williams, Ma, Prejean, & Ford, 2007). Robotics also encourage student problem solving (Barnes, 2002; Mauch, 2001; Robinson, 2005; Rogers & Portsmore, 2004), and promote cooperative learning (Beer, Hillel, Chiel, & Drushel, 1999; Nourbakhsh et al., 2005). Some studies also underscore robotics' potential to engage females and underserved youth in STEM learning; for example, female students are more likely to appreciate learning with robots than with traditional STEM teaching techniques (Nourbakhsh et al., 2005; Rogers & Portsmore, 2004).

Beyond the potential to influence youth learning, educational robotics is a unique technology platform with the potential to excite youth and motivate them to pursue STEM coursework and careers. The investigation of attitudinal outcomes has a long history in learning research, with recognition that youth affect can provide a motivational foundation for achievement outcomes (Alsop & Watts, 2003; Koballa & Glynn, 2007). Research has also shown that youth goals for STEM learning, their self-efficacy, and the value that they assign to STEM tasks and activities are likely to influence their level of engagement with learning activities (National Research Council, 2007). Studies show that robotics can generate a high degree of student interest and engagement (Barnes, 2002; Miller &