Chapter 82
Learning Geospatial Concepts as Part of a Non-Formal Education Robotics Experience

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ABSTRACT

In the increasingly modern and technological world, it has become common to use global navigation satellite system (GNSS), such as Global Positioning System (GPS), receivers, and Geographic Information Systems (GIS) in everyday life. GPS-equipped mobile devices and various Web services help users worldwide to determine their locations in real-time and to explore unfamiliar land areas using virtual tools. From the beginning, geospatial technologies have been driven by the need to make efficient use of natural resources. More recently, GPS-equipped autonomous vehicles and aircraft have been under development to facilitate technological processes, such as agricultural operations, transportation, or scouting, with limited or virtual human control. As outdoor robotics relies upon a number of principles related to science, technology, engineering, and mathematics (STEM), using such an instructional context for non-formal education has been promising. As a result, the Geospatial and Robotics Technologies for the 21st Century program discussed in this chapter integrates educational robotics and GPS/GIS technologies to provide educational experiences through summer camps, 4-H clubs, and afterschool programs. The project's impact was assessed in terms of: a) youth learning of computer programming, mathematics, geospatial and engineering/robotics concepts as well as b) youth attitudes and motivation towards STEM-related disciplines. An increase in robotics, GPS, and GIS learning questionnaire scores and a stronger self-efficacy in relevant STEM areas have been found through a set of project-related assessment instruments.

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INTRODUCTION

There is growing national concern that the United States' educational efforts are not producing enough STEM (Science, Technology, Engineering and Mathematics) professionals to meet the needs of our increasingly sophisticated and technological society, especially when compared to many other countries around the world. National reports such as the 2010 *Rising Above the Gathering Storm Revisited* (National Academy of Science, 2010), focus on the problem of U.S. competitiveness in STEM areas as summarized across educational reports and statistics. This diminishing STEM competiveness directly threatens our economy. For example, a sample from these business statistics indicates that, of Walmart's 6000 suppliers, at least 5000 now reside in China (Goodman & Pan, 2004). Engineering statistics are particularly frightening. As an example, during a recent period when two high-rise buildings were built in Los Angeles, a total of more than 5000 similar buildings were built in Shanghai (Fineberg, 2006).

Educational statistics from national and international reports further illustrate the need for transformative national reforms in STEM education, and the need to pursue more innovative educational strategies. In 2010, the World Economic Forum ranked the United States as 48th in the overall quality of mathematics and science education (World Economic Forum, 2010) and the ACT recently reported that 78 percent of high school graduates did not meet the readiness benchmark levels for one or more entry-level college courses in mathematics, science, reading and English (American College Testing, 2008). The United States government is becoming increasingly concerned about this STEM educational gap, and in response to these alarming national statistics, President Obama, in his 2011 State of the Union Address, identified this STEM education concern as our nation's new "Sputnik moment."

Finally, while there is little doubt that the United States will have to develop human potential in the STEM fields to stay competitive in the global economy, there is also the need for universal understanding of STEM concepts for everyone. For example, the National Research Council (2011) recently reported that:

a compelling case can also be made that understanding science and engineering, now more than ever, is essential for every American citizen. Science, engineering, and the technologies they influence permeate every aspect of modern life. Indeed, some knowledge of science and engineering is required to engage with the major public policy issues of today as well as to make informed everyday decisions, such as selecting among alternative medical treatments or determining how to invest public funds for water supply options (National Research Council, 2011 p1-1).

What makes an effective context for STEM education is steadily changing as computer technology influences the ways in which we can teach and learn about these important disciplines (Heid, 2005; Hegedus & Kaput, 2004). Instructional tools such as tablet computers, online simulations, robots, graphing calculators, and various other technologies are allowing schools and teachers to more effectively provide the instructional depth to STEM coursework and to teach core concepts in the context of advanced technologies (Anderson, et. al, 2011; Heid & Edwards, 2001; Whitemeyer, Nicoletti & DePaor, 2010). Integrated technology environments such as educational robotics may be particularly engaging and motivating for students in the instruction of STEM concepts (Gura & King, 2007). Students engaged in STEM lessons using such platforms have the opportunity to become involved in various interdisciplinary connections between science, technology, engineering, and mathematics that cover numerous achievement levels (Avanzato, 2000; Heer, Traylor & Fiez, 2003; Thompson, Heer, Brown, Traylor & Fiez, 2004).