Chapter 7
Robots Underwater! Learning Science, Engineering and 21st Century Skills:
The Evolution of Curricula, Professional Development and Research in Formal and Informal Contexts

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ABSTRACT

The underwater environment presents novel challenges that can facilitate unique learning experiences for students engaged in robotics programs. Although the number of underwater educational robotics programs is small by comparison to other forms of K-12 robotics initiatives, several do exist, which have varying learning goals, implementation approaches, and tools. This chapter describes an underwater robotics program using LEGO® MINDSTORMS® components and related materials for middle and high school students. The program, known as WaterBotics™, has undergone an extensive, four-year research and development phase and curriculum redesign effort. This chapter describes the theoretical framework

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of the curriculum design, the components and resources available in the challenge-based curriculum, and lessons learned about teacher practices and their relationship to student learning outcomes in physical science, Information Technology skills, engineering design, and engineering career interest. "Core elements of success" of the program and curricular adaptations are described in the context of a scale-up initiative that is adapting the curriculum for use in informal education settings.

INTRODUCTION

There has been tremendous growth in educational robotics programs in higher education, K-12, and informal education settings over the last several years, illustrated, in part, by the participation and publicity surrounding programs like U.S. FIRST Robotics and FIRST LEGO League. A number of universities and other organizations have developed underwater robotics lessons and some are actively promoting opportunities for students to engage in K-12 underwater robotics programs and competitions (Bretall & Furey, 2008; Carberry & Hynes, 2007; Giver & Michetti, 2008; Zande, Moulton & Sullivan, 2009). Robotics offers an exciting and engaging context for students to learn science and engineering concepts and skills, as well as an educational strategy to increase students' excitement and motivation for science, technology, engineering, and mathematics (STEM). It also offers students an opportunity to practice 21st century skills such as teamwork, problem-solving, and creativity and innovation. While the number of robotics programs available to K-12 students has ballooned over the last few years, most of these programs feature land-based robotics challenges. A smaller percentage of educational robotics programs, however, currently exist which use the underwater environment as the medium through which to present students with unique and novel challenges. While there are some common elements among the various existing underwater robotics curricula, such as a focus on competitions and related careers, there are also many differences among these programs. These range from the curricular and learning objectives, the tools and platforms used, the grade/age levels of students targeted, and assessment and program evaluation data available, to name a few.

The following pages describe the lessons learned from the development and widescale testing of an underwater robotics curriculum and associated teacher training and outreach program known as Build IT (in an earlier project) and now as *WaterBotics*™. The goals of the *WaterBotics*™ program are to increase student learning of physical science, engineering, and information technology (IT), and to increase interest in STEM and IT careers. The curriculum, the learning objectives, student and teacher assessments, the teacher professional development model, and the lessons learned about each are presented, as are the modifications underway for a national scale-up program taking place in both formal (classroom) and informal education settings.

WaterBotics™ is an innovative underwater robotics curriculum developed for use in middle and high school classrooms, which has been adapted and augmented for informal education programs. In addition to the learning goals in physical science, engineering, and IT content, *WaterBotics*™ aims to nurture specific 21st century skills, such as problem-solving, teamwork, and innovation/creativity, and to increase students' awareness and interest in engineering and IT careers. Originally named *Build IT*, the *WaterBotics*™ curriculum was developed through a three-year research and development (R&D) effort in which a technical university collaborated with middle and high school educators to develop, pilot, refine, and augment the curriculum with specific, just-in-time learning resources. The curriculum utilizes LEGO®