

# Chapter 62

## Robots Underwater! Learning Science, Engineering and 21<sup>st</sup> Century Skills: The Evolution of Curricula, Professional Development and Research in Formal and Informal Contexts

**Elisabeth McGrath**

*Stevens Institute of Technology, USA*

**Mercedes McKay**

*Stevens Institute of Technology, USA*

**Susan Lowes**

*Teachers College, Columbia University, USA*

**Jason Sayres**

*Stevens Institute of Technology, USA*

**Peiyi Lin**

*Teachers College, Columbia University, USA*

### 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 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.*

DOI: 10.4018/978-1-4666-4502-8.ch062

## 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 21<sup>st</sup> 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 *Water-*

*Botics*<sup>TM</sup>. The goals of the *WaterBotics*<sup>TM</sup> 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*<sup>TM</sup> 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*<sup>TM</sup> aims to nurture specific 21<sup>st</sup> 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*<sup>TM</sup> 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® MINDSTORMS® kits, the NXT programmable brick, and related equipment, along with a rich set of online resources to engage students in a series of increasingly complex, team-based challenges. Currently, the *WaterBotics*<sup>TM</sup> curriculum is being scaled up for use in four other U.S. cities in both formal and informal settings and aims to impact between 6,000 and 12,000 middle and high school youth by providing them with intensive science and engineering experiences based in a series of underwater robotics design and programming challenges. Through the contribution of partners with specialized expertise, the curriculum has been adapted to be used both in traditional classroom settings and for informal education delivery, such as summer camps and after-school programs, with a specific focus on girls.

25 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:  
[www.igi-global.com/chapter/robots-underwater-learning-science-engineering-and-21st-century-skills/88202](http://www.igi-global.com/chapter/robots-underwater-learning-science-engineering-and-21st-century-skills/88202)

## Related Content

---

### Reconceptualisation of Democratic Citizenship Education Against Social Inequalities and Electoral Violence in Zimbabwe

Monica Zembere (2021). *International Journal of Curriculum Development and Learning Measurement* (pp. 1-9).

[www.irma-international.org/article/reconceptualisation-of-democratic-citizenship-education-against-social-inequalities-and-electoral-violence-in-zimbabwe/285977](http://www.irma-international.org/article/reconceptualisation-of-democratic-citizenship-education-against-social-inequalities-and-electoral-violence-in-zimbabwe/285977)

### The Differences of Perceived Efficacy Between Pupils and Experts in Fostering 21st-Century Skills

Chi-Syan Lin and Cheng-Ying Lin (2022). *International Journal of Curriculum Development and Learning Measurement* (pp. 1-13).

[www.irma-international.org/article/differences-perceived-efficacy-between-pupils/290386](http://www.irma-international.org/article/differences-perceived-efficacy-between-pupils/290386)

### Gatekeepers to Education and Care: How Various Stakeholders Can Provide and Maintain Quality Experiences for Children and Families

Tiffany Ferrette (2022). *Handbook of Research on Innovative Approaches to Early Childhood Development and School Readiness* (pp. 55-69).

[www.irma-international.org/chapter/gatekeepers-to-education-and-care/299985](http://www.irma-international.org/chapter/gatekeepers-to-education-and-care/299985)

### Community Programs: Local School Boards and Anti-Bullying Programs

Ramona S. McNeal, Susan M. Kunkle and Mary Schmeida (2021). *Research Anthology on School Shootings, Peer Victimization, and Solutions for Building Safer Educational Institutions* (pp. 489-503).

[www.irma-international.org/chapter/community-programs/263483](http://www.irma-international.org/chapter/community-programs/263483)

### Autism Genetics: What Do We Know?

Laura G. Buckner and Jillian Yarbrough (2022). *Understanding Parent Experiences and Supporting Autistic Children in the K-12 School System* (pp. 138-151).

[www.irma-international.org/chapter/autism-genetics/294645](http://www.irma-international.org/chapter/autism-genetics/294645)