STEM Sea, Air, and Land Remotely Operated Vehicle Design Challenges for Rural, Middle School Youth

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Context

The STEM SEALs program at NFC explores methods for improvement of teaching and learning STEM in rural areas. While there is great need at all age levels, we focus on middle school students: old enough for multiple STEM fields, but also young enough to reach them early in their academic career.

Curriculum

Robotics is the central theme for the curriculum; the three disciplines Sea, Air, and Land add variety with a simple concept relating to fundamental structures found in nature, societal and governmental organizations, such as the armed forces.

Remotely operated and autonomously navigating vehicles – Sea, Air and Land

During the "Summer Institute", a week-long, six-day event, the students learn about robotics, build their own device, write computer code for it, test, improve, and compete with it against their peers.

The "Story"

Each of the devices, each Summer Institute, and each Discipline has a "story". From the beginning, the students are told about the purpose of their work, relating to non-classroom settings. Their motivation for why they would build, write code, and improve function increases by acquiring a deeper meaning.

Motivation: Taking a water sample for water quality testing; rescueing a stranded astronaut; transporting a sample for blood type testing

Research Design

The Next Generation of Science Standards (NCSS) promotes the creation of classroom environments where students learn to think on their own, solve problems, collaborate with each other, and communicate about science. This approach has been consistently associated with increases in student performance in science courses, gains in student knowledge of content, improvements in critical thinking, and positive changes in student behaviors and attitudes (1). The current study looks to build teacher self-efficacy through an informal experience where the STEM exploration was performed as "in development". The quick and easy just-in-time access to local STEM experts was thought to further support teachers in both understanding and practicing their teaching skills. The informal, yet intentional approach was designed to build upon best practices in PD in STEM.

For each of the disciplines, the Summer Institute was the culminating event, bringing students, local teachers, and college faculty together. Each group, design team, review team, and expert team joined their knowledge and skills developed during previously held separate meetings. The expert team consists of college (STEM) faculty and independent researchers, while the design team consists of all expert team members and a selection of local middle school STEM teachers. The review team was formed solely from middle school teachers. Some but not all of the teachers participated in multiple roles.

Data Acquisition

All participants, students, teachers, and college faculty provided feedback through surveys conducted before and after selected critical moments. The questions focused on engineering design self-efficacy, level of motivation, confidence about success, and feelings of anxiety. This instrument underwent a rigorous process to establish validity and reliability (2). To assess the impact of the STEM SEALs experience on educators, a series of paired-samples t-tests were conducted. The False Discovery Rate (FDR) (3) method was used to maintain an overall Type I error rate of 5 %.

Results

Composite	Before Mean (SD)	After Mean (SD)	Mean Difference (Post-Pre)
Explaining	3.95 (1.29	4.79 (0.58)	0.84
Analysis/Debugging	4.15 (0.99)	4.48 (0.72)	0.33
Relevance	4.42 (1.12)	5.00 (0.48)	0.58
Integration	4.39 (1.09	5.08 (0.74)	0.69
Resources	4.42 (1.38)	5.42 (0.79)	1.00
Lesson Planning	3.75 (1.53)	4.67 (0.86)	0.92
Coding Concepts	3.63 (0.96)	4.08 (0.81)	0.45
Decomposition	4.75 (0.75)	5.08 (0.90)	0.33
Problem Solving	4.50 (0.60)	4.79 (0.45)	0.29
Abstract/Generalization	4.33 (1.30)	4.25 (1.42)	-0.08
Coding Skill	3.13 (1.49)	3.13 (1.49)	0.00
Pattern Finding/Algorithms	4.00 (1.13)	4.00 (1.13)	0.00
Automation	3.33 (1.50)	3.33 (1.50)	0.00

There were two significant differences between pre- and post-institute composite scores. First, there was a significant difference on the *Confidence in Doing Engineering Design.* The mean difference of 0.35 corresponds to a medium effect size of 0.6 standard deviations. There were no statistically significant differences in educator motivation, potential for success, or anxiety. There were also significant differences between pre- and post-institute scores on the *Self-Efficacy in Explaining when Teaching Computational Thinking*. The mean difference of 0.85 corresponds to a medium effect size of 0.7 standard deviations.

1. Boddy, Watson, & Aubusson, 2003, Burris & Garton 2007, Gordon, Roger, Comfort & McGee, 2001
2. Carberry, Lee, & Ohland, 2010
3. Benjamini & Hochberg, 1995

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