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First-hand Experience of Elementary School Teacher for Implementing STEM Education in the Summer Camp

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Abstract

This study aimed to investigate the effectiveness of science, technology, engineering, and mathematics (STEM) curricula in cultivating gifted elementary school students' high-order thinking skills in summer camps. This paper adopted the quasi-experimental research (one-group pretest-posttest design) and used paired-samples T test. 20 participants' changes in their cognition of learning were collected through the experiment, and their learning motivations and status of completing assignments were observed. The results showed that STEM curriculum intervention can improve gifted students' cognitive and problem-solving abilities.

Key words: STEM education, gifted students, higher-order thinking skills and quasi-experimental research

Introduction

Well-developed, problem-solving skills are essential for any student enrolled in a science, technology, engineering, and mathematics (STEM) course as well as for graduates in the workforce[1]. Gifted children's problem-solving skills are not dependent solely on how academically gifted they are[2]. Therefore, regardless of intellectual capacity, how to teach gifted students problem-solving skills and consequent high-order thinking skills to meet their specific learning styles for informal curriculum is an important topic.

To the best of our knowledge, formal instruction in elementary school classrooms often lacks challenge for the gifted learner since courses in regular classrooms sometimes have a relatively narrow range of topics, minimal investigation of concepts, repeated drill and practice, and yearly repetition. Taking this issue into account, many extra and after school activities (e.g., State Science Fair, math club, environmental club), provide children with experiential learning that incorporates problem solving and/or creativity and design skills[3].

According to Lai Poh Emily Toh's et al.(2012) systematic review, educational robotics (ER) was able to aid in child's behavior or development. The core principles of educational robotics are involvement of students in discussing problems, solving problems, working with their peers, and combining their knowledge in order to construct their robots. Robots in elementary school helped promote problem-solving skills, collaboration, logic and scientific inquiry in children as they became involved in the process and construction of their artefacts for their robotic projects[4, 5].

The research presented was designed to address the need for demonstrating the efficacy of ER project-based learning in promoting student use of higher order thinking skills (analytical, creative, and practical). Specifically, this research was conducted to evidence the potential of Project-Based Robotics Learning (PBRL) to improve a gifted learner's problem-solving capacity to the higher order cognitive demands imposed by these unique ER PBL challenges.

Strategies to implement STEM Curriculum in the Summer Camp

A. Foster potential abilities for 21st century

The purpose of STEM education is to develop the higher-order thinking abilities for 21st century workplaces and to increase workforce in STEM fields.

According to the National Academy of Engineering, students need to begin associating the possibilities in STEM fields with the need for creativity and real world problem solving skills[3]. However, long-term independence of subjects and the lack of link between subject and real life, it is difficult to train students to have the ability to solve real-world problems and even make them lose their interest in studying in the field of STEM. Thus, The strategy of Project-Based Robotics Learning(PBRL) is of great significance for some gifted students suffering from application problems.

B. Project-Based Robotics Learning (PBRL) to enhance STEM curriculum development

Empirical evidence suggests the effectiveness of robotics as a learning complementary tool in tertiary education[6].

Educational robotics is a specific application of K–12 engineering education and offers students physical manipulatives that are familiar and easy to work with as they participate in the engineering design process. In addition, students have many opportunities for use of the accompanying programming language elements that allow them to test variable settings and receive immediate feedback.

Project-based Learning (PBL) has been one of the most usual learning theories. In fact, PBL proposes to engage students in investigative activities, such as creating artifacts or products based on robots[1, 6].

This guiding-research focus motivated us to consider designing a brief but significant learning experience for gifted children that would introduce them to educational robotics via an integrated robotics themed module.

C. Definition of Giftedness: Triarchic Theory of Intelligence

In traditional definitions of giftedness, general intelligence has long served as a major factor in identifying gifted children.

Today, however, most theories of intelligence also consider personal and environmental factors. Triarchic Theory of Intelligence developed by Sternberg (1996). The theory defines intelligence as the collective and balanced ability to adapt, shape, and select the environments to accomplish one′s goals as well as the goals of society[7].

According to this theory, three types of intelligence, analytical, creative, and practical, are needed to be successful in education and life. Analytical intelligence abilities involve analyzing, evaluating, comparing, and contrasting. Creative intelligence abilities comprise inventing, discovering, imagining, and supposing. Practical intelligence abilities involve implementing, using, applying, and seeking relevance[3, 7].

Importantly, these three types are not static or determined characteristics of a person but rather dynamic factors that can be influenced by personal and environmental factors. So far, it has been demonstrated that gifted abilities are better identified in childhood by means of triarchic teaching and that it is possible to enhance the three intelligence domains in students through education.

Methods

Educational robotics intervention model is known as ER which integrate the STEM curriculum. A total of 20 gifted students (aged 10-12 years) were selected from Public elementary school, Tainan City, Taiwan. The majority of students in the study were male (male students= 16, female students = 4). The majority of students reported not having experience with educational robotics prior to this session (none or minimal = 18 students, some = 1 students, significant = 1 student). This study primarily adopted the quasi-experimental research (one-group pretest-posttest design) and used the qualitative observation data as supplementary. Participants received educational robotics intervention model in 16 two-hour sessions. Learning effectiveness test was assessed, and limited efficacy of **pretest** and **posttest** measures was analyzed using paired t test (p < .05).

Learning effectiveness test and task-completed worksheets were used as measurement tools. This study was using Learning effectiveness test include problem which asks students to comprehend the principles of sensors, power machinery, and electronic circuits and program coding for the robot based on logical thinking. Furthermore, task-completed worksheet encouraged students to understand the problem, Make a plan, carry out the plan and look back on your work as representation of problem-solving skills. During the intervention period, children built robots following standard lessons and detailed instructional models. In these task-completed worksheets, the teacher again supported tribrachic thinking abilities.

Preliminary results

Data analysis for learning effectiveness test and task-completed worksheets shown in Table 1 indicates significance for pretest/posttest differences (p < .05) individually across all four levels of cognitive demand, and also for the aggregate analysis. The practical strength of these mean differences for all analyses is substantiated by large effect sizes, ranging from 0.76 to 3.69.

TABLE I
Pretest–Posttest Learning effectiveness test

Domain	*M*	*SD*	*SEM*	*df*	*t*	*p*	†ES
Coding							
Pre	2.55	0.69	0.15	19	11.05	0.000*	3.69
Post	4.80	0.52	0.12				
Electric							
Pre	2.00	0.65	0.15	19	5.88	0.000*	1.65
Post	3.15	0.75	0.17				
Machinery							
Pre	2.20	1.01	0.23	19	7.91	0.000*	1.75
Post	3.85	0.88	0.20				
Sensor							
Pre	2.00	0.73	0.16	19	3.24	0.004*	0.76
Post	2.55	0.76	0.17				

Note. n=20,
*$p < .05$, two-tailed, paired; †Effect Size

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