Impact of Programming Robots and Drones on STEM Attitudes

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Abstract

Hands-on activities can effectively engage students and promote learning. This paper presents the results of a one-week long summer camp for middle school students. The objective was to impact the attitudes of the participants towards science, technology, engineering and mathematics (STEM) fields. The participants of the camp were from underrepresented groups from two rural school districts. The camp provided opportunities to the participants to learn programming of robots for a maze running competition. This activity was followed by learning how to program quadcopter drones. Several teams of participants then programmed their drones to fly an obstacle course to compete in a ‘drone-derby’. The research design was a within-subject pre-post design. Participants of the camp were administered a validated math and science attitude survey at the beginning and after completion of the camp. This survey measured several dimensions of attitudes. The differences in attitudes between male and female participants were observed. In addition, a survey to determine the effectiveness of the camp was given to the students at the end of the camp.

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Keywords

STEM, computational thinking, drones, programming, middle school

Introduction

Active learning has a positive impact on students’ cognitive engagement and thus on learning\textsuperscript{1-3}. Active learning can be in many forms such as project-based learning, collaborative learning, and cooperative learning. However, an important element to consider is that the active-learning strategy must support cognitive engagement to foster deeper learning. Authentic learning environments have been shown to be particularly effective for cognitive engagement of learners. The two important attributes of an authentic learning environment are real-world relevance and competing solutions to the problems being solved\textsuperscript{4}. More recently, the construct of ‘computational thinking (CT)’ is being researched for its role in developing the problem-solving skills of students. Computational thinking is considered to complement mathematical thinking, scientific thinking and the engineering design thinking\textsuperscript{5} (Wing 2006). Five essential dimensions of CT identified by the ISTE/CSTA project\textsuperscript{6}. These dimensions are 1) confidence in dealing with complex problems, 2) persistence in solving difficult problems, 3) tolerance for ambiguity, 4) dealing with open-ended problems, and 5) communicating effectively.

This paper provides details of a five-day summer camp for middle school students from a rural county in Alabama. The design of activities of the summer camp is anchored in the construct of
an authentic learning environment based on active learning with the aim of developing the skill of computational thinking of the participants. The impact of the summer camp on the attitudes of participants towards STEM is reported in this paper. This work is supported through a grant from the FAA NextGen Portfolio Management and Technology Development Office, Unmanned Aircraft Systems (UAS) R&D Program.

Method

Participants

A total of 20 middle school (7th and 8th grades) students participated in the camp. The students were recruited from the local school district through the schools’ administration and teachers. All participants self-identified as African-American.

Materials

Programmable robots, Ozobots (Fig. 1a) ([www.ozobot.com](http://www.ozobot.com)) were utilized to teach programming. Students learned how to program the Ozobots with the Ozoblockly programming environment (Fig. 1b). This environment transferred the program optically to the Ozobot. Next, students were introduced to the Parrot Mamba quadcopter (Fig. 1c) ([www.parrot.com](http://www.parrot.com)). The Mamba drones consisting of a ‘cannon’ that could shoot miniature cannon balls, and a ‘gripper’ that could pick up and drop items were programed with the Tynker (Fig. 1d) ([www.tynker.com](http://www.tynker.com)) programming environment. The Ozobots and Mambas were programmed using iPads. Both the programming environments were drag and drop that supported the learning of computational thinking rather than learning a programming language. The project team had previously piloted the use of these programmable quadcopters and robots during two half-day sessions at the local middle schools as part of ‘UAS Road Shows’.

![Figure 1: Hardware and Programming Environments](image)

(a) Ozobot
(b) Ozoblockly
(c) Mamba Drone
(d) Tynker

Procedure

There were several presentations and hands-on activities during the 5-day camp. The participants were given a presentation on physics of flight and on aircraft controls. This was followed by hands-
on practice on a large screen flight simulator. During the camp, students were introduced to Excel and learned about data entry, calculations using formulas and graphing. The participants were also given presentations on unmanned aerial systems, introduction to computer architecture and algorithms. Representatives from the FAA participated in the activities of the last day of the camp and provided informative talks interacting with the students. The student participants gave presentations as two-member teams on a specific use of unmanned aerial systems. The participants then learned how to program the Ozobots first on a simulator and then on the hardware. This activity was followed by a maze-running competition between student teams (Fig. 2).

Figure 2: Programming the Ozobot

Having gained confidence in developing algorithms and programming the Ozobots, the participants then learned programming of the Mamba drone and operation of the gripper assembly. Programming was done using the drag-and-drop environment of Tynker. The drone teams (4-members) then programmed their drones to run an obstacle course that included dropping a ‘humanitarian aid package’ at a specific location and returning back to base.

A previously validated 65-item math and science attitudes surveys were administered to the middle school participants at the start and then at the end of the one-week camp. The 65-items of the survey loaded on five dimensions including (1) Mathematics Importance and Usefulness (D1); (2) Mathematics Enjoyment and Aptitude (D2); (3) Science Enjoyment and Aptitude (D3); (4) Science Importance and Usefulness (D4), and (5) Math and Science Instruction (D5). The instrument measured participants’ attitudes using a 5-point Likert scale from strongly disagree (1) to strongly agree (5). A post-camp survey solicited participants’ opinions about the camp on 5-point Likert scale. Participants were given presentations on topics such as physics of flight, unmanned aerial system, algorithms and programming, and using spreadsheets. Representatives from FAA also gave a presentation about the FAA and interacted with the students during their Ozobot and drone competitions. A post-camp survey was also administered at the end of the camp.

Results

It was observed that as a result of the simulated programming of the Ozobot and then the hardware, the participants developed an appreciation of the importance of planning in problem solving. While preparing for the maze-running, most of the students soon realized to calibrate their Ozobots’ responses to the commands such as ‘move 5cm’. Similar planning was observed during the planning/training phase of the quadcopter obstacle course competition. Participants started looking at the response of the quadcopter to the commands to identify optimal speeds to drop the ‘aid
package’ at the target location. Thus, the camp participants were exercising the components of ‘computational thinking’.

The repeated measures t-test analysis was carried out on the responses to the attitudes survey. Since 3 students did not take either the pretest or post-test, data was analyzed for the N = 17 participants (Males = 7, Females = 10). The pre-post analysis did not yield statistically significant (p < 0.05) changes in attitudes. However, a positive change in attitudes was observed in the responses to 74% of the survey questions. An analysis by gender showed that males had a positive change in responses on 86% of the questions while females had a positive change on 58% of the questions. There was no statistical difference between the mean responses of males and females on the pretest. A similar result was seen on the post-test except for two questions. The pretest responses to the question “You can get along perfectly well in everyday life without science” resulted in a mean of 2.30 for females and 3.29 for males. On the post-test, the responses to the same question resulted in a mean of 2.00 for females, and 3.57 for males. The difference in the post-test mean was statistically significant (p < 0.05) difference. Similarly, the pretest responses to the question “I remember most of the things I learn in mathematics” resulted in a mean of 4.00 for females and 3.86 for males. The mean of the responses to the same question on the post-test was 3.70 for females and 4.29 for males showing a statistically significant (p < 0.05) difference between the means on the post test.

The data was grouped into the five dimensions of attitude and then analyzed. The results are given in Table 1.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Pretest Mean</th>
<th>Post-Test Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>D1: Mathematics Importance and Usefulness</td>
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<td>3.90</td>
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<tr>
<td>D2: Mathematics Enjoyment and Aptitude</td>
<td>3.49</td>
<td>3.48</td>
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<tr>
<td>D3: Science Enjoyment and Aptitude</td>
<td>3.50</td>
<td>3.27</td>
</tr>
<tr>
<td>D4: Science Importance and Usefulness</td>
<td>3.63</td>
<td>3.92</td>
</tr>
<tr>
<td>D5: Math and Science Instruction</td>
<td>3.54</td>
<td>3.71</td>
</tr>
</tbody>
</table>

Table 1: Pre-Post Comparison by Dimension and by Gender (* p < 0.05)

The post-camp survey indicated that the students enjoyed their experience. Some of the typical responses are given in Figure 3 and statements below:
Figure 3: Typical Responses to the Camp

- I liked programming the ozobot, programming the drone, and talking with the FAA.
- First off, I liked when we flew the flight simulator. Secondly, I enjoyed when we programmed the ozobots. Lastly, I enjoyed when we programmed and coded our drones in the gym.
- I liked how we got to use our iPads to program the ozobots. I also liked the tour we got of the different labs.
- Learned how to program a drone and ozobot and the competitions and visit to the wind tunnel

Discussion

The camp activities were very useful in exposing the participants to exciting hands-on activities and developing their computational thinking skills. The attitudinal survey data showed a positive movement in the attitudes of the camp participants towards STEM. Statistically significant changes were few, most probably due to the small sample size. The data indicated that the camp strengthened the attitude of the females that one cannot get along in life without science. In general, the participants showed a positive change in all the attitudinal dimensions as shown in Table 1. More specifically, there was a statistically significant positive change for the males in math enjoyment and math and science instruction post-test.

References


