A Robotics Workshop for Middle School STEM Teachers

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Abstract: Youths are naturally intrigued, fascinated, and drawn to robots. By utilizing robotics to excite and open up youths to technology, more students will consider STEM (science, technology, engineering, and mathematics) disciplines. In June 2010, the Mercer University School of Engineering, with support from Boeing, organized a five-day robotics workshop for middle-school teachers of STEM subjects. The objective of the workshop was to introduce robotics into the middle school curriculum to inspire students to study and pursue careers in math, science and engineering. This paper discusses our experience in organizing the workshop, describes the robotics kits that were used, Georgia STEM standards that were covered, and a summary of workshop participants responses to a survey at the end of the workshop.

Keywords: K-12 Initiatives; Robotics; STEM; Middle School.

INTRODUCTION

In June 2010, the Mercer University School of Engineering offered a five-day robotics workshop for middle-school teachers of STEM subjects. The objective of the workshop was to show teachers how robotics can be used to teach STEM subjects. For example, students can learn applied physics concepts, such as mechanical advantage in design of gears; speed and friction, by observing a robot's movement in response to motor actuation; and electronics sensors through sensor integration, calibration, and measurements. Without formal training in structured programming, students can also learn to program using visual module programming. The content of the workshop was also aligned to the state of Georgia's STEM Performance Standards. Eight middle school teachers attended the workshop. The teachers were drawn from middle schools in 3 central Georgia counties – Bibb, Crawford, and Houston. Three teachers, including one gifted-education teacher came from a school in Bibb County, two teachers came from a school in Crawford County, and three teachers, including a gifted education teacher, came from a school in Houston County. The teachers were divided into groups of two. Three groups had teachers from the same school, and the fourth group had the gifted education teachers. The reasoning behind selecting teachers from the same school was so that they could support one another.

This paper discusses our experience with organizing the workshop. The paper also describes the robotics kits that were used, curriculum for the workshop, state of Georgia STEM standards that were covered, and comments of the workshop participants on the last day of the workshop.

ROBOTICS EDUCATIONAL SET

There are a wide variety of robotics sets [1]. However, few sets include standards-based curricula and activity packs. We decided to use one of the educational sets from LEGO Education, the educational division of the LEGO Group. Some other advantages of LEGO educational kits include [1]:

- Students may be familiar with LEGO® products, which they associate with fun activities.
- Students have the opportunity to construct robotic subsystems, which are then combined together to form functional robots. This contributes to the hands-on learning experience.

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- Most Lego products are durable.

Some disadvantages of LEGO educational sets include [1]:

- Time spent in constructing robot systems. Some students may require longer time than others, and this may slow down the entire class.
- As the kits get used by more groups of students, there could be missing parts in some of the educational kits. If this is not detected early enough, progress in the classes may be impeded. Replacement of parts may lead to increase in the cost of equipment

The robotics set that was used in this workshop was the *Team Challenge and ROBOLAB™ - 8 Pack* [2]. This is a general-purpose robotics starter set. The set consists of:

- Eight Team Challenge kits. Each kit includes touch and light sensors, motors, and a programmable RCX Brick, which serves as the robot's brain.
- ROBOLAB™ 2.5.4 Software with Training Missions and Site License. This software teaches students, at any skill level, how to write programs for the programmable brick, which is used to control a robot. The site license allows the software to be installed into every computer in a classroom.

Team Challenge sets are also available in groups of 12-packs, 4-packs, and 1-pack kits. A 12-pack kit contains 12 identical robots; an 8-pack kit contains 8 identical robots, etc. The 8-pack kit was used in conjunction with another LEGO product - the *Robotics Educator Software and Classroom License* [3]. This software includes a robotics curriculum that uses the *ROBOLAB*™ software and the *Team Challenge* building sets. The *Robotics Educator* software includes lesson plans for 1, 3, 6, and 9 weeks. This software was designed by Carnegie Mellon University's National Robotics Engineering Consortium, and it is aligned with standards developed by the American Association for the Advancement of Science, the National Council of Teachers of Mathematics, and the International Technology Education Association.

During the workshop, each group of two teachers shared a robotics kit. At the end of the workshop, each school that was represented at the workshop was given 1 – 2 kits.

WORKSHOP CURRICULUM

The topics that were covered in the five-day workshop are described in this section.

Part 1 - Introduction to Robotics

The morning session of the workshop started with a brief overview on how robotics can be used to teach math, science, engineering, and technology subjects. It also included an overview on activities the teachers will be participating in during the workshop. Each group assembled a Tankbot robot - a robot built in the form of a tank (Figure 1). Other activities included learning how to program the tankbots to perform simple tasks such as: moving forward/backward for a specific amount of time, and making a 180-degree turn. During the afternoon session, each group assembled touch-sensor and light-sensor attachments for their respective robots. They also wrote simple programs to illustrate the use of these sensors.

Part 2 - Introduction to Programming

More programming exercises were performed by the teachers; these included Motors and Sound Programming, as well as programming with the touch and light sensors. The teachers also learned how to program with loops, and how to use modifiers to change parameters such as the power level of motors, and the sensitivity of the light sensors. The teachers learned how to trouble shoot the robot's programming block.

Part 3 - Gears and Speed with Constant Distance

The teachers learned about gears and gear ratios. They investigated the relationship between gear ratios and robot speed by measuring how gears affect the speed of a robot.

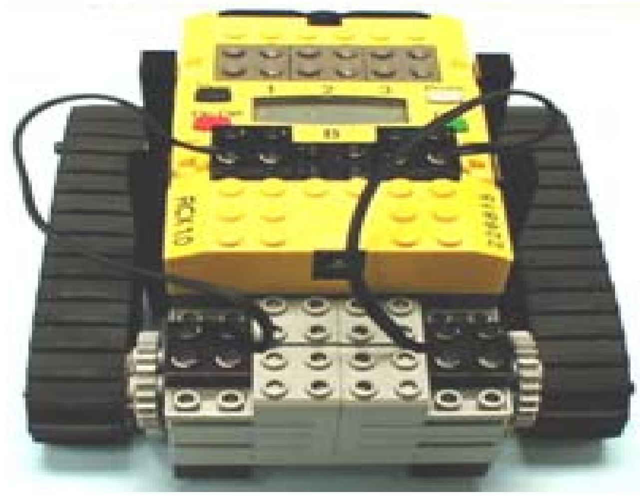

Figure 1: *Tankbot* Robot [2].

Part 4 - Gears and Speed with Constant Time

The teachers continued to investigate the relationship between gear ratios and robot speed by seeing how changing the gear ratio affected how fast the robot traveled 2m.

Part 5 – Measurements

These were experiments that involved measuring the distance a robot travels with different sized wheels and constant time. Other experiments included the use of measured data to make predictions about future measurements, then seeing how these predictions compared to actual results.

Experiments in parts 1, 2, and 3 were carried out on the 1st, 2nd , and 3rd days, respectively. Experiments in parts 4 and 5 were originally scheduled for the 4th and 5th days, respectively, but ended up being run on the 4th day. **This occurred because by the 4th day, the participants had grasped the content of robotics to the extent that they had completed all of the assignments for day 4 by noon. Consequently, the instructors allowed the participants to run the experiments for day 5 on the afternoon of the 4th day.** On the 5th day, the teachers performed various programming projects including: programming a robot to navigate a maze, and programming a robot to draw certain shapes/letters.

Part 6 – Other Presentations

On the last day of the workshop, workshop presenters discussed and presented the following:

a) Unifying Concepts that related to energy transformations, connections to different content areas, sequences, friction, technology uses, electricity, simple machines, heat, efficiency, and utility
b) URLs to Websites with activities that participants could used in various STEM disciplines
c) How to use “Expansion with Inquiry” relative to Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science
d) Robotics and connections to students’ everyday lives
e) Strategies for increasing STEM students’ scores on state assessments.

STATE OF GA PERFORMANCE STANDARDS ADDRESSED BY THE WORKSHOP

As part of the workshop, the teachers were given a list of suggested activities that they could carry out in their respective schools. The state of Georgia Performance Standards [4] that were addressed by the curriculum of the workshop are listed below:

SCSh3. (Science Characteristics of Science high School Standard #3).
Students will identify and investigate problems scientifically.

S8CS3. (Science Grade 8 Characteristics of Science Standard #3).
Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.

S8CS4. (Science Grade 8 Characteristics of Science Standard #4).
Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities utilizing safe laboratory procedures.

S6CS5, S7CS5, and S8CS5. (Science Grades 6, 7 & 8 Characteristics of Science Standard #4).
Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters.

S7CS6 and S8CS6. (Science Grades 7 & 8 Characteristics of Science Standard #6).
Students will communicate scientific ideas and activities clearly.

S8CS8. (Science Grade 8 Characteristics of Science Standard #8).
Students will be familiar with the characteristics of scientific knowledge and how it is achieved.

S8CS9. (Science Grade 8 Characteristics of Science Standard #9).
Students will understand the features of the process of scientific inquiry.

EVALUATIONS BY WORKSHOP PARTICIPANTS

On the last day of the workshop, participants were asked to evaluate the workshop. This evaluation was administered on the last day of class. The first part of the evaluation involved a Likert Scale instrument. Names were not required on the instrument. Instructors did, however, check to ensure that the number of evaluations returned matched the number of workshop participants. This Likert Scale used a 5point scale, which included the following:

5 = Exceptional
4 = Above Average
3 = Satisfactory
2 = Below Average
1 = Poor

Table 1 contains a summary of participants responses to the Likert Scale evaluation instrument.

Table 1: *Likert Scale Items/Questions and Likert Scale Numbers per Participant Responses Number*

Likert Scale Items/Questions	Likert Scale Number/ Participant Responses' Number				
Provided clarity of workshop expectations	5/7*	4/1	3/0	2/0	1/0
Content consistent with objectives	5/7	4/1	3/0	2/0	1/0
Relevant to participants' educational goals	5/6	4/1	3/1	2/0	1/0
Instructors knowledgeable	5/7	4/1	3/0	2/0	1/0
Instructors provided adequate feedback	5/7	4/0	3/1	2/0	1/0
Instructors communicated content well	5/7	4/0	3/1	2/0	1/0
Instructors related to participants' interests and needs	5/7	4/1	3/0	2/0	1/0
Examples or personal experiences used to help get points across	5/6	4/2	3/0	2/0	1/0
pace was appropriate	5/6	4/2	3/0	2/0	1/0
Content arranged in a clear and logical manner	5/6	4/2	3/0	2/0	1/0
Participants' concerns or problems addressed	5/8	4/0	3/0	2/0	1/0
Instructors modeled teaching strategies that met needs of participants' students.	5/7	4/1	3/0	2/0	1/0

* For 5/7, the number 5 represents "Exceptional" on the Likert Scale and the number 7 represents the number of participants who check 5 for the specific Item or Question.

Participants were also asked to provide narrative responses to specific evaluation questions, which have been itemized below. These questions are stated exactly as they were on the evaluation instrument. Some of the evaluation questions and responses of the participants are shown below:

1. **What did you like best about the workshop?**
   - Small groups.
   - Hands-on experience.
   - Being allowed to work and learn at a pace that was comfortable to participants.
   - Free kits to take back to school.
   - Programming robots.
2. **What did you like least about the workshop and what were the weaknesses of the workshop?**
   - Limited workspace.
   - Wiring icons together in the programming software was frustrating.
   - Sharing a kit.
   - Having to go back and write the curriculum for technology
3. **How do you plan to use the content of this workshop?**
   - Use it to teach programming.
   - Use it to teach metric measurements, and to reinforce scientific methods.
   - Use it to teach motion and simple machines.

LESSONS LEARNED

First of all, we would like to state that the gifted teachers did not perform better than the other teachers in the workshop. Of the four groups, one group finished significantly faster than the other three groups (approximately 10 minutes); this was not the gifted teachers group. One group finished significantly later than all groups (approximately 15 minutes). Our lessons learned fall into four categories: (1) the workshop itself; (2) challenges requiring intervention; and (3) participants' concerns regarding using the content and negotiating the standards. What we would do differently for the next workshop encompasses (a) having less furniture in the room to allow participants more workspace; (b) stating up front that wiring the icons in the programming software may be labor intensive and they need to be patient with respect to their learning curves. (c) Each group wanted their own kit; however, the extent to which this is possible is contingent upon future funding.

We also learned that giving the participants the science standards is not enough. Our participants wanted actual lessons that addressed each standard and how robotics can be specifically used in each standard from a pedagogical perspective. This is very feasible and we will attempt to provide more specific lessons in the next robotics workshop. Some participants verbalized the need for videos with teachers and students working together in a classroom situation using robotics. This may not be feasible because schools have very strict rules regarding videotaping in classrooms.

We observed that the participants had a clinical view of the experiments. They thought that experimental results would perfectly fit the theory. As they discovered inconsistencies, they showed frustration with developing code, as shown in response to question 2 in the previous section. As they modified the programs, some failed to take into account that there are other environmental factors affecting their experimental results. For example, the amount of dust on the wheels and on the floor contributed to inconsistent distances; also, differing amounts of ambient light in different parts of the room affected their light sensors. To prevent these types of frustrations, an explanation will be made on the environmental factors that may affect their experimental results.

Relative to the Likert Scale used, we gleaned that we do not have any specifics relative to each item on the scale. For example, if a participant checked 3 (Satisfactory) for an item, useful knowledge would encompass the thinking behind the choice so that we understand why the item was not "Above Average." Consequently, we will add a comment section below each Likert-Scale item.

CONCLUDING REMARKS AND FUTURE WORK

In this paper, we have described a robotics workshop for middle-school teachers of STEM subjects. The objectives of the workshop were to introduce robotics into the middle-school curriculum to inspire students to study and pursue careers in science and engineering. Comments from workshop participants indicate that the workshop was very useful; hence, we have provided a section on lessons learned. In future offerings of the workshop, we intend to include activities that make use of rotation sensors, and present teaching activities that are discipline specific, for example, math and physical science. The current robotics kit that was use in this workshop [2] did not include rotation sensors. The robotics curriculum in the *Robotics Educator* [3] software package has examples of activities that require the use of rotation sensors. These activities will be adapted to GA standards in future offerings of the workshop.

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