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This paper describes a unit designed to promote the development of narrative writing skills among 5th grade students through the use of LEGO robotics. Over the course of four, two and one-half hour sessions (one day per week for four consecutive weeks), the students learned how to construct and program robots, write and present a proposal to complete a mission, and connected the learning to their personal experiences with Hurricane Irma. The students began the activity with prior knowledge of World War II and Hiroshima. After learning the basics of building and programming robots, they were presented with a scenario similar to the impact of the bomb drop in Hiroshima – a city in ruins with survivors in need of supplies. Students took the role of engineers to work in pairs to create a proposal, which stated the problem and defined, and justified, a solution to pick up, and deliver, supplies through a specially-designed course using their robots. After the proposals were presented, and accepted, students programmed their robots according to their proposed solution; the activity required students to apply mathematical skills to measure distances in order to traverse parts of the course. Writing reflections were collected to determine individual student understanding and to include an additional element of writing. A final culminating activity required the students to write a narrative piece to relate the events of Hiroshima to their personal experiences with Hurricane Irma.

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LEGO robotics, cross-curricular, mathematics, writing, social studies

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Introduction

Writing has been at the forefront of education since the onset of formal educational settings and I argue it may be more important now than ever before. The increase in technology has allowed more and more students to have access to texting and social media – avenues where proper grammar and formal writing take a back seat. In addition, educational policies of the 21st Century (e.g., No Child Left Behind and Race to the Top) have increased the demand on teachers to improve students' reading and writing abilities. The issue at hand then becomes how to teach writing, or apply the concepts learned, in an engaging and meaningful way for students. Furthermore, with such time constraints placed on classroom teachers, finding a way to incorporate more learning in less time would help to alleviate some of the stresses felt by educators. I posit the time constraints can be reduced, and learning can become engaging and meaningful, through the implementation of cross-curricular units.

I have experience incorporating LEGO robotics into mathematics curricula and found the students to be more engaged in the learning when the robots were implemented. In addition, studies have reported positive learning outcomes in mathematics classrooms (i.e., Ardito, Mosley, & Scollins, 2014; McDonald & Howell, 2012; Martinez Ortiz, 2015) and in science classrooms (i.e., Williams, Igel, Poveda, Kapila, & Iskander, 2012) when learning and understanding were gained through the incorporation of robotics into the curricula. We, the teachers and faculty involved in this intervention, were interested in stretching the boundaries of previous robotics interventions to determine if positive results can be achieved in the domain of writing.

The Problem

In rural Georgia, the writing deficits of elementary students are documented through annual Georgia Milestones exams. These deficits may not be more severe than other rural areas around the nation, however, the number of English Language Learners (ELs) and students living in poverty substantially impacts this area; any additional support to meet the needs of all learners would be welcomed by faculty and administration. One local elementary school reached out to the university at the start of the 2016-2017 school year to inquire about possible programs to support their students. After school stakeholders participated in a meeting with university faculty it was decided LEGO robotics could be a possible solution. School faculty and administration decided to bring a sampling of their students to campus for a robotics intervention intended to promote narrative writing skills. The school faculty and administration felt the robotics writing intervention showed positive results and early in the fall of 2017 the school reached out to the university to determine if it would be feasible for their students to participate in another robotics program, but with a new group of students. After meeting to determine the school's expectations for the program the following unit was developed.

Methods

The school's focus was to integrate Social Studies and narrative writing, with priority given to students performing below Georgia Milestones proficiency levels. Since the University's Innovation Studio is supplied with eight LEGO Robotics kits, it was agreed a total of 32 students would participate in two separate programs of instruction. Each program supported 16 students and lasted four weeks. The students met for four

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consecutive weeks, one morning per week, for 2.5 hours each morning – a total of 10 hours of instruction; one group participated in November, 2017 and the second group participated in January/February, 2018.

A unit was designed to integrate Social Studies, narrative writing, mathematics, and technology through the use of LEGO Robotics. Since the students were studying World War II in Social Studies, one of the teachers suggested the students read an article about the bombing of Hiroshima (Hiroshima, 2012). The article was read in school prior to the students' first robotics session and the topic became the overarching focus of the intervention. The plan was to have students learn about robots, build and program a robot, and be presented with a final challenge – helping survivors of Hiroshima obtain necessary supplies. The final challenge would require them to work in pairs to complete a proposal, program their robots to complete the final challenge, and the culminating activity would require the students to write a narrative piece connecting their understanding of Hiroshima to their experiences with Hurricane Irma.

The Unit

The 4-day unit was designed to incorporate robotics education, building, programming, collaboration, problem-solving, planning, and design. The first class began with an introduction to robots through a PowerPoint presentation and class discussion – what they are and what they do. The students were provided with a LEGO Mindstorms EV3 instruction manual and robot parts – they were required to work in purposefully chosen pairs to build the basic driving base (see Figures 1 and 2). In addition, students were instructed to add the color sensor to their build for use in the final challenge. Once the robots were built (which utilized a significant part of the class time) students were introduced to basic programming blocks used with the Mindstorms software. To end the class, students were asked to participate in a closing reflection activity which required them to write a response to two questions: (1) What did you like about today? Why? and (2) What is a robot and what does it do?

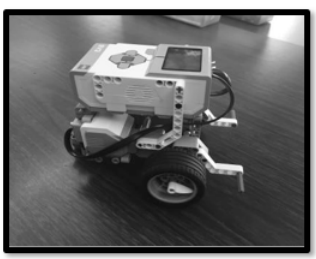

Figure 1. Driving base viewed from the right.

Figure 2. Driving base viewed from the left.

The second class began with a quick review initiated by the question "What is a robot and what does it do?" The discussion concluded by determining the different methods for turning the robot – drag turns, pivot turns, and point turns – and scenarios in which one may be favored over the others. Drag turns involve both wheels turning, but at different speeds. Pivot turns require one wheel to be stopped while the other wheel moves. Point turns are tight turns in which both wheels move at the same

speed, but in different directions. Once the discussion ended students were required to program their robot to move in a square. This task required basic programming blocks, but allowed students to apply their knowledge of straight movement and turning. As student pairs completed this task, they were asked to create different polygon shapes (e.g., triangles, pentagons) as a form of differentiation and to allow other student pairs time to complete the task.

A major focus of the final challenge was the requirement of the robots to follow a line, therefore the next challenge required students to program their robots to follow a colored line and to stop on a specific color. This introduced students to programming logic (if/then statements) known as switches and loops. Differentiation was implemented in this activity by allowing early finishers to add "song and dance" to their robots after completing the designated challenge, which was done by adding sound blocks in the programming and creating unique movements with the programming blocks.

Once all student pairs had completed these tasks they were presented with the final challenge – to deliver supplies to the survivors of Hiroshima. The students were shown the course specifically designed for this unit (see Figure 3), which required the robots to pick up supplies and deliver them to the survivors of Hiroshima. It was at this point the students were asked to write a proposal to present to the "Disaster Relief Administration" with their plan to complete the mission. The students were presented an outline with the following required information for the proposal:

- What is the problem?
    - o Write 1-2 sentences to describe the problem to be solved.
- What is your solution?
    - o Write 4-5 sentences to describe your solution plan.
- How do you plan to implement your solution? What will you need to do? What will your robot need to do? How will you accomplish this?
    - o Write 5-10 sentences to describe how your team plans solve the problem. Describe the programming blocks you will use.

Students were asked to collaborate to complete this task and informed they would present their solutions to the entire class and teachers at the next session. The remaining class time was devoted to writing (approximately 30 minutes) and time to complete the proposal was provided during their regularly scheduled support time at school (teachers reported an additional 30-45 minutes was provided).

Figure 3. View of the Final Challenge course.

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The third meeting began with a quick review of robot functions and programming blocks – moving straight, turning, loops, switches. After the discussion, the students presented their proposals. Upon "acceptance" of the proposals students were tasked with programming their robots to complete the final challenge. The final challenge required the robots to follow a line to reach the supplies (the robots were programmed to stop when the color sensor "saw" the red tape), attach the supplies to their robots, travel a specified distance to another line following section, and then follow the line to the survivors to deliver the supplies (the robots were programmed to stop when the color sensor "saw" the green tape). In order to travel the specified distance between the supplies and second line, the students applied mathematical understanding to measure the distance and determine how far their robot traveled in one rotation of the wheels in order to determine how many rotations would be required to travel to the next line following segment.

The students worked diligently for the entire class period and were all actively engaged throughout the time period. It was rewarding to witness their perseverance to work through the issues at each stage – they did not give up. After working through several trials to obtain success it was common for students to be "jumping up and down" in excitement and "high-fiving" one another; they experienced success due to working hard and not giving up. One pair of students completed the challenge fairly quickly and were asked to build a basket to transport the supplies that could easily be attached and unattached from everyone's robot during the challenge – they appreciated the opportunity to complete the additional project and collaborated well to design a solid, lightweight structure. By the end of the session, most student groups had completed the challenge, and only needed to complete some fine-tuning at the next, and final, session. However, there were two groups who only partially completed the challenge at this point and it was decided additional support would be provided at the final session to ensure their success. This class ended with students completing a written reflection to address the following questions: (1) What challenges did you encounter today as you programmed your robot to complete the final challenge? And (2) How did you and your partner successfully conquer the challenge? Be specific.

The final session began with a quick discussion reviewing the functions of a robot and the functions of the different programming blocks. Once the discussion ended, time was devoted to completing the programming of the final challenge. Those teams who successfully completed the challenge were given the opportunity to program a celebratory song and dance upon reaching the survivors as the instructors worked with the two teams in need of support.

After all teams had successfully programmed their robots to traverse the course, each student pair was asked to present their solution by having their robot complete the challenge while the rest of the class watched, which allowed each team of students to witness similarities and differences among the movements of each team's robot. After all of the student pairs had completed their presentation, a final discussion was conducted for students to share the hurdles they encountered and strategies for overcoming those hurdles in order to achieve success in the final challenge. This discussion afforded students the opportunity to understand how similar issues can be approached from different perspectives, thus creating multiple solutions to similar problems.

The culminating activity was introduced to the students – write a narrative document comparing their understanding of the events of Hiroshima to their recent experiences with Hurricane Irma. The remaining class time was devoted to student writing (approximately 30 minutes) and support was provided to students as needed. All of the students required additional writing time, which was provided upon their return to school.[1]

Results

An important result of this intervention, although subjective, was the improvement in the students' ability to write; when students were asked to write a reflection at the end of the first session there was a lot of hesitation and their final products barely answered the questions posed, many writing samples reflected incomplete sentence structure. This response was mirrored in the second session when students were asked to write a proposal. The students struggled to get started, even with the prompts given. They were questioning the teachers and instructors about what to write and required much scaffolding to put words on the paper even though they were provided with an outline to guide their thinking. By the third session, their reflections seemed easier to complete, which I speculate was due to their active engagement during the session.

When the culminating activity was announced, although the students were not excited about the writing aspect, they were able to begin writing rather quickly. It was impressive to see 15 of the 16 students feverishly writing - some even asking for additional sheets of paper! One student, who the teachers reported had a history of struggling to organize their[2] thoughts in order to complete writing assignments, was facing the same struggle with this activity. When I sat down with the student I asked specific questions to guide their thinking to support the facilitation of the writing assignment. Some of the questions I posed were:

"What did you do during the hurricane - did you stay home or evacuate?"
"Where did you go?"
"Why did your family choose to leave the area?"
"Did the people of Hiroshima have the opportunity to evacuate?"
"What happened during the bombing of Hiroshima?"
"How is this similar to, or different from, the hurricane?"

After asking each question, I gave ample wait time for the student to respond and make notes on their paper. Once I completed the questioning I told the student "you have everything you need to tell your story now" and allowed them to begin writing. To everyone's surprise, this student had completed an entire page of writing by the end of the session.

Discussion

Although I do not have statistics or student artifacts to provide concrete data on the effects of this unit on students' narrative writing skills, it has provided a solid foundation from which I can move forward with a formal research plan in the future. I can also conclude this unit provided students with a fun, engaging way to apply their understanding of the events of Hiroshima. One teacher reported "The kids couldn't

[1] The information reported in this paper is based upon the November 2017 session; at the time of this writing, the January/February 2018 session had not begun.

[2] The word "their" is chosen to maintain anonymity in regard to the students' gender.

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stop talking about it on the way home! Yay!" (V. Woodruff, personal communication, November 16, 2017), which provides further evidence of the students' positive response to the intervention. Additionally, I have found robotics can move past the STEM disciplines to support learning in other academic areas.

This intervention has provided some basic, subjective findings to promote continued investigation into the benefits of this type of curriculum to promote narrative writing skills. I intend to continue with type of intervention and would like to make this unit and/or sessions available to more students at more schools, however, funding and logistics will need to be investigated in depth in order to make this feasible.

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