Preparing Ugandan Secondary Teachers for Robotics and Technology Competitions

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ABSTRACT

This paper describes the details of an intensive one-day robotics workshop designed to introduce the basics of educational robotics to 10 Ugandan secondary information technology teachers. At the end of the workshop, a survey was administered to the participating teachers. The workshop was successful in sparking teachers' interest in robotics. Five out of 10 teachers participated in a regional robotics competition with their own school teams 5 months after participating in the workshop. The other 5 teachers planned to participate in the same regional robotics competition in the following year. This study suggests that robotics programs offer an opportunity for students in developing countries such as Uganda to become deeply involved in STEM activities and develop an interest in STEM careers. Further research might focus on teacher professional development that is a critical factor mediating students' access to quality STEM education in developing countries.

Keywords: robotics, STEM, workshop, teacher, competition

INTRODUCTION

There is a growing evidence about the efficacy of structured informal learning environments in terms of increasing students' academic achievement and raising awareness with regard to science, technology, engineering, and mathematics (STEM) careers (Bell, Lewenstein, Shouse, & Feder, 2009). Informal learning environments can be instrumental in promoting inquiry-oriented STEM learning to support the development of critical thinking skills, creativity, design, and innovation in a technology-driven world (National Academy of Engineering, 2005). The use of robots in informal learning environments has a potential to further improve critical thinking skills, creativity, design, and innovation. Some researchers suggest that robots can potentially transform the teaching and learning process (Chambers & Carbonaro, 2003; Jonassen, 2000). The use of robots enables students to translate abstract mathematics and science concepts into concrete real-world applications (Nugent, Barker, Grandgenett, &Adamchuck, 2010).

Educational robotics is seen as a promising approach to increase students' STEM attitudes and knowledge (Nugent et al., 2010). Studies show that robotics can increase students' interest in STEM careers (Robinson, 2005; Rogers & Portsmore, 2004). The recent improvements in cost and operation of robots make robots a useful teaching

and learning tool with a natural engagement capacity for students (Nugent et al., 2010). However, most teachers are not prepared to teach robotics (Alimisis et al., 2007; Kim et al., 2015; Matarić et al., 2007). There were several attempts to provide training for teachers to foster their understanding of educational robotics (e.g., Cohoon, Cohoon & Soffa, 2011; Yuen, Ek & Scheutze, 2013).

Results regarding influence of trainings on teachers' knowledge and attitudes were encouraging. In particular, teachers' knowledge and motivation to teach robotics increased after the trainings (e.g. Stubbs & Yanco, 2009; St. Pierre & Christian, 2002). Despite the studies reported above, the number of studies related to teacher professional development about educational robotics is limited (Kay, Moss, Engelman, & McKlin, 2014). This paper describes the details of an intensive one-day robotics workshop designed to introduce the basics of educational robotics to 10 Ugandan teachers with no prior experience in robotics.

Participants and Workshop Settings

Galaxy International School Uganda (GISU) is a private international school located in Kampala, Uganda (Figure 1). The school uses Cambridge International curriculum and prepares students for the International General Certificate of Secondary Education (IGCSE) examination and Cambridge A level examination. Both exams are recognized worldwide and administered by Cambridge International Examinations (CIE). GISU is one of the best schools in Uganda with its facilities and highly qualified international staff (GISU, 2015).

To promote STEM, GISU created and hosted a technology and robotics competition called GISUTECH. GISUTECH has four categories: LEGO Sumo, LEGO Maze, Short Movie, and Hardware Control (GISUTECH, 2015). To prepare for the upcoming competition, GISU invited 10 Ugandan secondary school information technology teachers from private, international, and public schools to participate in a workshop. Eight participants were male and 2 participants were female. Their age ranged from 25 to 35 years. Their average teaching experience was 10 years.

Participants completed a full day workshop about the basics of educational robotics under the guidance of the first author. The first author previously coached middle and high school robotics teams primarily including girls and minorities in the United States. He was recognized for his work encouraging girls to choose STEM careers by National Center for Women and Informational Technology (NCWIT) in 2014.
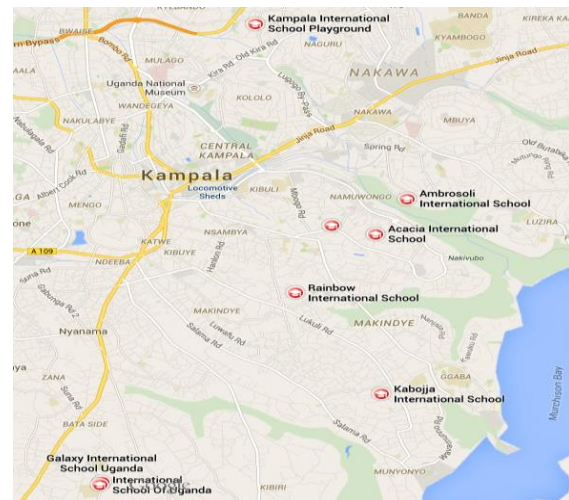

Figure 1. Map of schools participating in GISUTEH competition

Robotics Kit

We looked at various robotics kits, and decided on the Lego MindStorm kit based on recommendations from Klassner and Anderson (2003):

1. Cost: A single LEGO MindStorms NXT kit, with 750 construction pieces, sensors, and programmable hardware, costs approximately US$200; thus, it is one quarter the cost of a HandyBoard-based robot kit and one tenth the cost of an ActivMedia-based robot kit—two of the more commonly used platforms in colleges (Figure 2).

2. Flexibility: The LEGO MindStorms platform supports a suite of reusable snap-together sensors (touch, rotation, light, temperature), effectors [motors, lights, infrared (IR) emitters], building blocks, and a programmable control

unit that can serve as the basis for a wide variety.

3. Student Interest: Many students have played with LEGO building blocks as children, therefore, they are intrigued with working on LEGO-based classroom exercises. (p.13)

Figure 2. Lego Mindstorms NXT kit

Robotics Workshop

A full day workshop was held in Galaxy International School Uganda on January 10, 2015 to publicize GISUTECH competition. Our primary goal was to introduce the basics of educational robotics to our participants (Figure 3).

Figure 3. Participants building the LEGO MindStorm robots

We covered the following knowledge and skills during the workshop: (1) the basics programming techniques for robotics, (2) debugging and troubleshooting in robotics, (3) analyzing and fixing hardware problems for robotics, (4) integrating robotics to STEM curriculum, and (5) introducing the basics of running successful structured informal learning environments designed to prepare students for robotics competitions.

We primarily used free online resources that could be accessed after the workshop due to the time limitation. These online resources also provided detailed information about using Lego Mindstorms NXT kit for educational purposes.

The first online resource was the online robotics course developed by Jennifer S. Kay at Rowan University Laboratory for Educational Robotics. This course was specifically developed for teachers who are interested in teaching robotics in K-12 school settings with a grant from Google. The course includes a brief overview of educational robotics, basic concepts of the software, hardware and programming, and methods to teach robotics in STEM classes. The course includes 5 units. Each unit is expected to last 4-6 hours. We covered the first unit in our workshop and asked the participants to complete the rest of the course content after the workshop on their own. Each unit includes step-by-step video tutorials for teachers and self-assessment of the content covered in the tutorial. Each unit provides detailed instructions that can even be followed by beginner Lego Mindstorms NXT programmers (Kay, 2015).

The second online resource that we introduced in the workshop was Computer Science Student Network (CS2N), online learning management system. This resource is a Moodle based curriculum that teaches robotics with embedded assessment tools. This resource was developed for students by Carnegie Mellon University, which is a leading institution in educational robotics. We showed our participants how students can use this resource to build and program Lego Mindstorms NXT robot from scratch. This resource requires log in and it allows teachers to keep track of their students' progress.

After introducing the two online resources, we asked our participants to complete a robotics challenge to demonstrate their knowledge and skills that they acquired during the workshop. All participants were able to program their Lego Mindstorms NXT robots to follow a straight line and say "hello" when the robot stopped. We also gave two more challenges to our participants so that they can further demonstrate their knowledge and skills: the maze solver and the lego sumo. These two challenges are adaptable enough for participants to develop a creative and functional design, while being structured enough to focus participants on the importance of correct

programming and accomplishing the goal within the accepted rules. In the maze solver challenge, the robots must reach the finish line by moving through the maze as fast as possible (Figure 4). In the lego sumo challenge, the robots are placed in a sumo ring and they try to push each other out of the ring (Figure 5). At the end of the workshop, GISU student robotics team presented their various robot designs to our participants. Workshop concluded with awarding the certificates of completion.
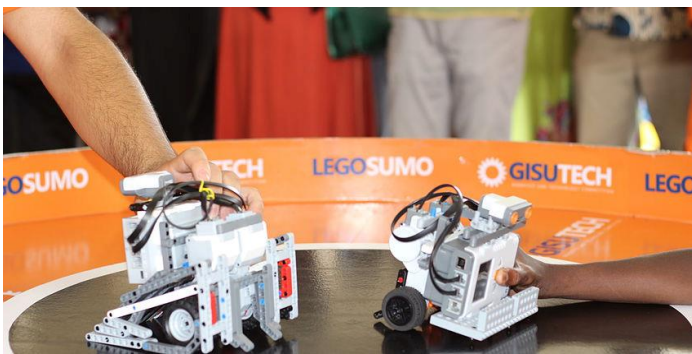

Figure 4. Lego maze

Figure 5. Lego Sumo robots

We decided to offer ongoing professional development support for our participants through video conferencing. However, we realized that the Internet bandwidth in Uganda was not conducive for video conferencing. Therefore, we provided assistance to our participants via e-mail. Our participants requested to participate in supplementary workshops through webinars. As we stated earlier, this request was not feasible given the current technological infrastructure in Uganda.

Workshop Assessment

At the end of the workshop, we asked the participating teachers to respond to the following statements. The first three items were answered with "Yes" and "No." The rest of the items were answered with a 5-point Likert scale (5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, and 1-Strongly Disagree).

1. I will coordinate and teach LEGO MindStorms NXT robotics in my school.

2. Educational robotics is a useful context for learning STEM concepts.

3. I am in favor of the introduction of robotics technologies at my school.

4. I personally find STEM subjects interesting.

5. Educational robotics can be easily integrated into many STEM courses within a middle and high school context.

6. This workshop has increased my knowledge of engineering.

7. This workshop has increased my knowledge of educational robotics.

8. This workshop has provided me with some instructional ideas.

9. I found this workshop to be interesting and fun.

10. I found this workshop to be useful or practical for me as a teacher.

11. I would recommend this workshop to other teachers.

All participants responded "Yes" to the first three items.

Table 1. Mean, standard deviation, maximum and minimum values for items 4-11.

Questions	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Mean	4.8	4.7	4.5	4.8	4.5	4.6	4.6	4.7
SD	0.42	0.48	0.71	0.42	0.53	0.52	0.52	0.48
Maximum	5	5	5	5	5	5	5	5
Minimum	4	4	3	4	4	4	4	4

The workshop evaluation gave us insights to improve the workshop for the following offerings. We were encouraged to see that the majority of our participants selected "Strongly Agree" option for items 4-11 (Table 1). Five out of 10 teachers participated in a regional robotics competition with their own school teams at GISU five months after the workshop. The other five teachers did not participate in the robotics competition with their school teams, but they brought their students to watch the competition and they planned to participate in the competition in the following year.

CONCLUSION

An intensive one-day robotics workshop proved to be successful in encouraging 10 Ugandan secondary information technology teachers to start robotics programs in their own schools. We acknowledge that there is a need for more robotics workshops that are long term. However, it was encouraging to observe what these teachers were able to achieve with such a limited introductory robotics training. Our workshop played a key motivational role in sparking teachers' interest in robotics and helping them seek additional robotics training. We think that robotics programs offer an opportunity for students in developing countries such as Uganda to become deeply involved in STEM activities and develop an interest in STEM careers. We also think that teacher professional development is a critical factor that mediates students' access to quality STEM education in developing countries.

Acknowledgments

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