Secondary School Robotics Education in Camarin High School: Developments and Challenges for Improvement

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Abstract

Camarin High School is one of the schools in the Philippines that is making an initiative in improving STEM education through robotics education. In this paper, the authors report the development of a robotics program for students in junior high school. Through the Teacher Training Program of the Japanese Government for international teachers, localized challenges were identified and advances in technology education were examined for consideration. This report is hoped to provide useful insights to both practitioners of robotics education and initiators in a similar situation.

Keywords: Robotics Education, STEM Education, Robotics Club,

1. Introduction

Various research has substantiated positive effects of robotics in Science, Technology Engineering and Mathematics (STEM) education. According to Mosley, et al.[1] robotic cooperative learning metho-dologies promote STEM interest and enhance critical thinking of students. Kanlhofer and Steinbauer revealed the significant impact of educational robotics on pupil's mathematics and scientific investigation, teamwork and social skills. [2] A systematic review of Bareto and Benitti showed that the most common result on the topic is that the use of robotics helps the understanding of concepts related to the STEM areas.[3]

Robotics activities can be beneficial to students in various ways. Participation of the youth in robotics summer camps, academic year clubs and compe-titions increase their STEM content knowledge, their perceived problem solving skills, and their interest in engineering careers.[4] Robotics clubs positively change students perception of robots, humans and society while they increase skills in scientific creativity and science process skills.[5]

Various robotics competitions reported positive impacts on students. Participants of FIRST LEGO League, FIRST Tech Challenge, and FIRST Robo-tics Competition show significantly greater gains in STEM related measures such as interest, careers, identity, involvement and knowledge.[6] RoboCup Junior has presented success on enhancing learning of STEM contents and skills for innovation and creativity among students partaking the com-petition.[7] Using Test of Science Related Attitudes (TOSRA), it has been shown that students who participated in a robotics competition had positive attitude toward science and areas such as social implication of science, normality of scientists, attitude toward scientific inquiry and adoption of scientific attitudes.[8]

Robotics programs are seen to yield positive outcomes. First LEGO league robotics program conveyed prospects for learning 21st century skills such as systems thinking, decision making, problem solving, teamwork, conflict resolution, flexibility, perseverance and self-management.[9] Students acknowledged that learning skills in cooperation and communication as well as

collaboration as one of the best results of an educational robotics course.[10]

Robotics programs can be done with various approaches. Instructional strategies such as modeling, coaching, scaffolding, examples and case studies provide fruitful experience to children.[9] A project-based robotics program can be beneficial to students in implementing informal instruction in science, technology and problem solving.[11] Challenge-based learning approaches in robotics are able to enhance student's course achievement and motivation.[12]

This paper focuses on the initiative and development of a school robotics program for a public general high school primarily enthused by the participation in science and technology fairs. Localized challenges and advances in technology education are explored for consideration.

2. Robotics in Camarin High School

Camarin High School is the largest public junior high school in Caloocan City and one of the largest schools in the Philippines in terms of population size. The school caters four grade levels – grade seven, grade eight, grade nine and grade ten with ages 13, 14, 15, and 16 respectively. As of 2019, it has 347 staff members and 9923 students divided into 224 sections.

Camarin High School has Special class sections comprised of students selected based on their elementary school grade and screening examination scores. The program started in 2017 with the first section in grade 7 rolling out as the years pass. As of 2019, there are 3 sections of special class, one for grade 7, grade 8 and grade 9. Aside from the regular core-subjects, additional Mathematics, English and Science classes are taken by the students of Special class. Students of the program are also required to do research projects during their grades 9 and 10.

National Science and Technology Fair (NSTF) is an annual science fair organized by the Department of Education of the Philippines that aims to promote Science and Technology and a culture of innovation among the youth. It also aims to identify the most creative and innovative student researchers from junior and senior high school who shall represent the country in the international science fairs. There are four categories, one of which is Robotics and Intelligent Machines category.[13]

In 2018, a robotics team was formed to satisfy the need of producing entries for science and technology fair competitions. Robotics team members were selected from grade 10 students based on their Science and Mathematics performance as well as their dedication to give time to the endeavor. Members received basic training on micro-controllers and proceeded to develop their own projects. Figure 1 shows the first robotics team.

Fig. 1. Training of robotics team members

Robotics club was also offered as an after-school activity to students interested in robotics. Since training was only given to members of the robotics team, a 3-day workshop was conducted to teach the students the fundamentals of robotics and micro-controllers.

In 2019, robotics class was offered as a non-credit elective subject for grade 7 and grade 8 students of Special class and an option for research for grade 9 special class. Figure 2 shows the robotics class.

Fig. 2. Robotics Class

The teacher-in-charge of the robotics team, robotics class and robotics club was selected among the existing faculty members based on exposure to related seminars and training. The teacher-in-charge (the first author) also attended available training in robotics prior to formation of the robotics team and start of the robotics class.

3. Developments in Robotics Education in Camarin High School

This section explains initial developments in robo-tics education at Camarin High school as well as the problems encountered during the development.

3.1 *Use of Arduino*.

Arduino was used to introduce the students to micro-controllers. Arduino is an open-source electronics platform based on easy-to-use hardware and software.[14] It is a low-cost alternative to popular robotics kits. An Arduino set was purchased for the robotics team. Sensors and other materials were bought according to need.

3.2 *Use of Simulations*

To cater more students in the workshop, Tinkercad was used. It is a free and easy to use application for 3D design, electronics and coding.[15] Students who can borrow and bring laptops to school were strategically grouped to form teams. Simulation is a way to reduce the need for more Arduino kits and to prevent unnecessary breakage of devices.

3.3 *Flipped Learning*

With a huge amount of resources available in the internet and video streaming platforms such as YouTube, robotics team was advised to utilize differentiated resources. Flipped learning is an approach in which students watch recorded videos for homework and tasks are completed when the teacher is present.[16] The use of flipped learning with the available online resources is a way for the teacher-in-charge to save time on instruction and focus more on solving problems, monitoring progress and giving feedback.

3.4 *Project-Based Learning*

Since the initial purpose of the robotics initiative is to provide entries to science and technology fairs, students studied robotics based on the needs in the project the groups are working on. Project-based learning is a teaching method in which students are engaged in complex real-world tasks that result in a product or a presentation (e.g. [17]). The use of project-based learning enabled the students to learn tools and techniques required for developing their projects in a short amount of time.

3.5 *Problems Encountered*

With the establishment of a local robotics program, several problems were encountered such as (1) topics and projects to be included in robotics program (class, team and club) and effective practices in teaching to students (2) further training of teacher-in-charge project development and supervision and (3) low-cost devices and instructional materials.

4. Challenges for Improvement

With the participation of the teacher-in-charge on Teacher Training Program of the Japanese Govern-ment for foreign teachers, several activities have been executed and expected to bring improvement in the robotics program of Camarin High school.

4.1 *Seminars*

Seminars on microcontrollers and mechanisms for the teacher-in-charge provided technical training and pedagogical examples in teaching robotics as well as the outline of topics for a classroom-based robotics program. Since the teacher-in-charge had no formal training on technology education, the second author provided several seminars in Hiroshima University. Topics are listed as follows:

(i) Software and Programming:
  (a) C coding
  (b) state transition diagrams.
(ii) Electronics:
  (a) pull-up and pull-down registers
  (b) transistors
  (c) oscilloscope
  (d) relay logic circuit
(iii) Hardware and microcomputer:
  (a) digital input and output
  (b) AD converter
  (c) PWM
  (d) real time interrupt
  (e) DA converter
  (f) motor driver
  (g) bypass capacitor
  (h) sensors
(iv) Mechanism
  (a) linkages
  (b) pulleys, gears and cams
(v) Teaching:
  (a) connecting the electrical devices on the breadboard
  (b) wiring layout diagram

The topics cover programming, microcomputers, electronics, mechanics and robotics and are selected based on practicality.

4.2 *Robotics Projects*

The first author has built various low-cost robotics projects during the teacher training to be used as common projects for project-based-learning in Camarin High School. The building process was also a coaching example in guiding students in creating their projects. The following projects were created:

(i) Tank type robot
(ii) Remote controlled robot
(iii) Edge avoidance and obstacle avoidance robot

Creating robotics projects integrate connected robotics topics. The tank-type robot project involves the basics of making robot bodies and mechanics. The remote-controlled robot project deals robotic control practices without using microcontrollers. The edge avoidance and obstacle avoidance robot project includes topics on sensors, actuators and micro-controllers.

4.3 Instruction Materials

Guidance on the use of Raspberry Pi is valuable to the teacher-in-charge in utilizing it as a low-cost computer for programming and project development. The authors explored the use of Raspberry Pi as an alternative to laptop computers in teaching Arduino. The teacher-in-charge is going to prepare teaching materials for robotics class.

5. Conclusions

This paper reported that the robotics program of Camarin High School consists of the robotics team, robotics class and robotics club, primarily enthused by the participation in science and technology fairs. In its initial phase, flipped learning and project-based learning was utilized while using an Arduino kit. Simulation was used to cater many students. It also reported that the teacher-in-charge (the first author) is in the teacher training program of the Japanese Government and that he has received seminars in Hiroshima University and created robotics projects for enhancing teaching skills in robot education. The teacher-in-charge is going to prepare instruction materials for robotics class.

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