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Investigating STEM-based Learning Package for Enhancing Programming and Problem Solving Skills

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Abstract: This research aims to investigate the effectiveness of a STEM-based learning package to enhance the skills of problem-solving and programming. We design and develop the learning package which is consisted of the traffic model, self-directed worksheets, and the Sphero robot. In our design process, the students' knowledge integration and real-life based problem-solving skills were taken into account. Participants are high school students who are aiming major in science in the future. Research instruments and collection include skill assessments, satisfactory questionnaires and observation during the activities. The findings revealed that students had better understanding the program workflow, had improved programming skills, and had the high satisfaction levels from the learning. The average of overall students' satisfaction was 4.38 (SD=0.63).

Keywords: Collaboration, Problem-Solving Skill, Programming Skill, STEM Education, Learning Package

1. Introduction

Programming skills are important in the time of technological advancement. Programming skills are promoted in various organizations around the world. Programming knowledge and skills are required to develop everything such as internet of thing (IOT), machine learning, artificial intelligence (AI) and intelligent systems.

In Thailand, formerly, the high school curriculum was not established to acquire skills of basic programming, computational thinking and problem-solving skills. As a result, students' learning achievement in the computer science study in higher education was low because these students did not have sufficient understanding and knowledge of advance programming (Sochara, 2010). Likewise, other skills required in the computer science field, including creative thinking, problem solving and critical thinking were not focused to be taught in school (Gultekin, 2005). Therefore, students were lacking these important skills which are needed to flourish in life in the 21st century.

Currently, based on the Thai Education Policy for the high schools, the educational focus is to integrate learning methods using the principles of the STEM education. The STEM education consists of four disciplines Science, Technology, Engineering, and Mathematics. This teaching and learning method emphasizes on students' learning projects (Siripattrachai, 2013, Ioannou & Bratitsis, 2017). The STEM method is believed to promote the integrated learning in Thai high schools in order to develop essential computer competencies and encourage computing science literacy among students.

With the principles of the STEM education, teachers still have to choose appropriate instruments to support learning activities. The learning instruments must be appropriate for the characteristics of students which are hands-on, intellectually-stimulating, and entertaining. The Sphero Robots will be a reasonable choice for this circumstance. The Sphero robots are approachable, playful appearance and simple to use, despite containing complex technologies inside (Sphero Inc, 2012).

In order to comprehensively promote the higher order thinking skills and knowledge in computing science, we developed the learning package to provide experiences, improve student behavior, and also facilitate teacher in learning management. In this study, we aim to investigate how STEM-based learning package can enhance programming and problem solving skills by using Sphero robots with specific traffic model and self-directed worksheets.

2. Method

2.1 Participants and Classroom Study

This study involves 30 high school students who are aiming major in science in the future. They were divided into groups of 5 persons. Subsequently, the learning package was provided to these student groups. Figure 1 illustrates the learning flow of this preliminary experiment using our learning package. After the activity was done, students were asked to self-assess their programming and problem solving skill, then to take the questionnaire.

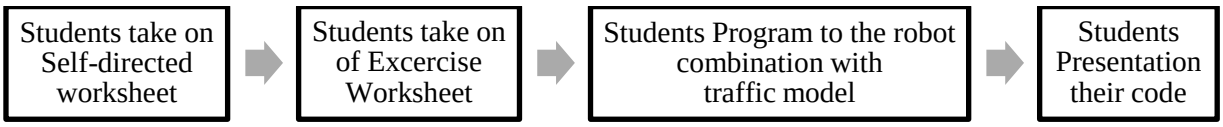

Figure 1. The Learning activity process.

2.2 Research Instrument

The research instrument is the learning package which is consisted of:

- The traffic model, the designed field for robots which is developed based on simulation map from the actual location.
- The self-directed worksheet, the programming practice consisted of 3 sections including concepts of programming, concepts of loop function, and concepts of condition which followed the Thai basic education core curriculum in technology (computing science) subject.
- The exercise worksheet, it provides engineering design process to solve problem real-life simulated situation requiring students to travel from the start point to the end point.
- The Sphero robot used in our experiment was the Sphero SPRK2 robot coding via the Sphero Edu application.

2.3 Measurements

2 types of questionnaires were designed and developed. One was for evaluating students' satisfaction. Another was for evaluating students' skills which included 12 items (6 items for programming skill and 6 items for problem solving skill). They both were developed according to 5-point Likert scale including strongly agree=5, agree=4, don't know=3, disagree=2, and strongly disagree=1 (Likert, 1932).

3. Results and Analysis

3.1 Programming and Problem Solving Skill Assessment

From analysis of students' self-assessment data, the results showed that the average score was 4.26 (SD=0.75). Out of the 12 items, 11 items had average score above 4.00. While, the highest score was the item "*the students were able to understand the workflow of the program better*" (Mean = 4.53, SD = 0.64), the lowest score was the item "*the students were less able to apply knowledge to daily lives*" (Mean = 3.87, SD = 0.83).

3.2 Students Satisfaction

The result of students' satisfaction toward the learning package was averagely 4.38 (SD=0.63). Out of the 10 items, 9 items had average score above 4.00. Only one item had average score below 4.00 that was "*Proper study time*" (Mean = 3.87, SD = 0.92). The highest score was the item "*The teaching and learning activity are interesting*" (Mean = 4.67, SD = 0.49).

4. Conclusion and Discussion

4.1 *How the Activity is Related to STEM Education?*

We observed students during doing the activity followed the step of the engineering design process. Figure 2 shows the students' engagement in the activity.

- *Ask*: Each group was able to identify the problems and determine which route would lead them to the destination with the least amount of time.
- *Imagine*: Students brainstormed and shared ideas about the best-possible route.
- *Plan*: Students designed and calculated speed time and distance.
- *Create*: Students programmed the robot following the plan.
- *Experiment*: Students tested the program, observed and adjusted.
- *Improve*: Students modified the code following the adjustments and reattempted the program.

(a) (b) (c)

Figure 2. (a) Students brainstorm for the practice worksheet, (b) Students try their code on the traffic model, and (c) Students improve the program.

4.2 How did the Activity Enhance Programming Skill?

Students were able to understand and explain concepts and how to process the program on the self-directed worksheet without teacher assistance. Likewise, students were able to control the robot to complete mission by applying knowledge that gained from the self-directed worksheet.

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