A LUPDA Assessment Model for Activities in STEAM Education

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Abstract. The Science, Technology, Engineering, Arts, and Math (STEAM) has become the buzzword in the field of education. Many studies have revealed the importance of STEAM education and proposed different strategies to enhance it, nevertheless, these strategies are not in perfect alignment with five disciplines of STEAM. Therefore, this study proposed an assessment model which can match each discipline of STEAM activities respectively, including Learning, Using, Practicing, Designing, and Applying (LUPDA). We piloted and reviewed this model through the STEAM learning activities of the Micro: bit-Obstacle Avoidance Car. Finally, the LUPDA model provides effective measurement thorough STEAM hands-on activity.

Keywords: STEAM · LUPDA · Assessment

1 Introduction

The National Science Foundation (NSF) began to use the term "STEM" in the 1990s, which represents the abbreviations for Science, Technology, Engineering, and Math [1]. With the announcement of the "Education Innovation Plan" by former US President Obama in 2010, STEM has further drawn educators' attention (House, 2010). Many pieces of research and policy reports have indicated the demand of STEM education. Even, some countries believe STEM education is a crucial factor to maintain the competitiveness in the global economy [2–4]. Furthermore, Yakman [5] proposed that arts should be included in STEM to become STEAM (Science, Technology, Engineering, Arts, and Mathematics) which help students to build engineering background with artistic aesthetics, particularly for engineering design.

Moreover, according to the employment forecast report issued by the U.S. Department of Labor [6], it revealed that employment opportunities in future jobs will be inextricably related to STEM-related occupations which will massively increase from 2016 to 2026. However, to our best knowledge, few studies have focused on developing a sound evaluation model corresponding to five disciplines of STEAM

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activities [7]. Therefore, this study aims to develop a model that includes those actions of *learn, use, practice, design* and *apply* based on the intrinsic objective of STEAM education.

2 Method

2.1 The Design of a LUPDA Evaluation Model

STEM education has become a global education trend. As a result, both formal learning environments and informal learning environments have launched STEM education-related courses. No matter in which learning environment, instructors always need to plan a series of related learning activities to increase cross-field knowledge so as to cultivate students' interdisciplinary skills [8, 9].

This study identified the actions to be taken by students in STAEM activities as five types: learning, using, practicing, designing, and applying, which correspond to science, technology, engineering, art and mathematics respectively.

1. Science is the main subject for students to master scientific knowledge and scientific laws to form a scientific spirit.
2. Technology is the concretization of science, that is, learners' ability to master, apply, and invent technology.
3. Engineering refers to the practical application of technology, which means that learners can use technology to carry out a systematic development process and able to evaluate or reflect.
4. Art asks learners to be innovate and able to think about design with the ingredient of aesthetics.
5. Mathematics is that learners must master the knowledge of mathematics as a foundation to synthesize other abilities.

The detailed descriptions are shown in Table 1.

2.2 Model Design

To measure these STEAM objectives and students' skills, this study defines five actions taken by students through *learn, use, practice, design,* and *apply* in STEAM activities.

In this study, we invited several researchers and experts to review the assessment principles in scoring until consensus being reached. At the same time, they have piloted and reviewed the rubric, as shown in Table 2.

3 Experimental Design

3.1 Participants

This study participants were fifth and sixth-grade students from five primary schools in South Taiwan. A total of 30 volunteers were recruited to participate in training workshop on the Micro:bit-Obstacle Avoidance Car (see Fig. 1). The participants were

Table 1. LUPDA evaluation model.

STEAM element	Qualities for evaluation
Science (Learn)	1. establish experimental hypotheses and verify them 2. collect data and analyze experimental results 3. summary and reasonable inferences based on the analysis
Technology (Use)	1. choose correct and suitable materials and tools 2. use materials and tools by following specifications 3. modify or design models according to device measurement
Engineering (Practice)	1. understand the function of each component in the activity 2. combine components and build a system correctly 3. diagnose the correctness of the constructed system and make corrections
Arts (Design)	1. designed system is aesthetic 2. show unique design ability 3. have imagination or creativity
Math (Apply)	1. use appropriate tools for measurement 2. display data in graphs 3. analyze the trend of data measurement

Table 2. Rubric for LUPDA evaluation model.

	1-point (minimal)	2-point (solid evidence)	3-point (exceeds expectations)
Learn	Hypotheses and verify	Collect and analyze	Reasonable inferences
Use	Choose materials and tools	Use materials and tools	Modify or design tool measurement
Practice	Know each component	Combine components and build a system	Construct system and make corrections
Design	Designed with aesthetic	Show unique	WITH imagination or creativity
Apply	Use tools for measurement	Display data in graphs	Analyze data from measurement

asked to complete a series of learning activities that are the hands-on activities related the STEAM education. Because five students could not complete the experimental procedure, their experimental data were deemed invalid and eliminated. To ensure that all groups can able to complete the specific tasks, other 25 students (17 males and 11 females) were assigned to different groups according to their prior knowledge, and each group is three to four students.

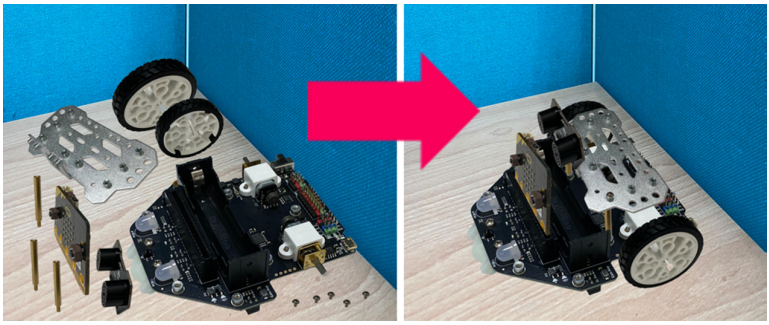

Fig. 1. Micro:bit-Obstacle avoidance car.

3.2 STEAM Activity

In this study, the STEAM learning activity was designed as five-phased projects centered on the micro:bit-Obstacle Avoidance Car. The activity tasks are divided into five projects. The tasks classified according to the difficulty mentioned above, and the difficulty are organized from easy to difficult. As shown in Table 3, this activity conducted students a progressive way (from easy to difficult). Through this course, students can have basic knowledge and concepts of programming.

Table 3. The task of Micro:bit-Obstacle avoidance car in STEAM activity.

No.	Task	Task content	Level
1	Assembly	Let the Obstacle Avoidance Car perform 4 functions: forward, backward, left, and right	easy
2	Basic features	Use the gray value sensor to complete the track	easy
3	Follow the line	Use ultrasonic sensors to avoid obstacles on the track	medium
4	Avoid obstacles	Use Bluetooth to control Obstacle Avoidance Car's left and right to complete the track	medium
5	Remote control	Accelerate Obstacle Avoidance Car in a straight line and complete the track	Difficult

4 LUPDA for the Micro:Bit-Obstacle Avoidance Car Activity

4.1 Evaluation Implementation

This study develops a scoring rubrics for the Micro:bit-Obstacle Avoidance Car Activity based on the LUPDA model. To pilot and review the LUPDA model and rubrics, researchers and experts repeatedly revised the model based on Micro:bit-Obstacle Avoidance Car Activity. Table 4 shows the LUPDA model with a detailed assessment principle of this example.

Table 4. LUPDA for Micro:bit-Obstacle avoidance car activity.

Element	1-point (minimal)	2-point (solid evidence)	3-point (exceeds expectations)
Science (Learn)	Understand the task target and try their car that it can complete forward, backward, left, and right	Repeatedly try their car on the track, and making it can follow the route	In addition to following the route, it can remotely control their car through Bluetooth
Technology (Use)	Successfully operate gray value sensors and ultrasonic sensors	According to task requirements, use correct sensors which are gray value sensor or ultra-sonic sensor	Control the degree of the sensors: 1) different paths successfully detected; 2) read the distance value and successfully avoid obstacles
Engineering (Practice)	Assemble the car body and install the battery	Connect obstacle avoidance car and micro:bit	Connect gray value sensor and ultrasonic sensor with their car
Arts (Design)	Use LED of mircor:bit on obstacle avoidance car	Design a unique and distinctive LED	Design LED that fit the situation, such as marquee
Math (Apply)	Calculate the distance between the obstacle avoidance car and the obstacle	After judging the distance of the obstacle, calculate the turning angle	Make a successful turn before the their car approaches an obstacle

5 Discussion and Conclusion

With the development of STEAM education-related practices, educators need to evaluate student work that does not rely on traditional knowledge and is not limited to specific activities. This study's contribution provides a framework called LUPDA, which helps educators understand students' interdisciplinary integration and measure students' learning performance in STEAM. Nevertheless, in terms of the required resources and the applicability of education, to realize the LUPDA framework applies to multiple STEAM activities, the measure remains to be solved.

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