A Study of Problem Solving using Blocks Vehicle in a STEAM Course for Lower Elementary Levels

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Abstract. STEAM education is currently one of the most important parts of the elementary school curriculum. If STEAM learning can cultivate good problem-solving ability, it will also help improve judgment and thinking abilities. Several voices in the literature have argued for cooperative learning in STEAM courses. Although the effectiveness of course learning often is evaluated using course feedback forms, there is comparatively little emphasis on whether a course succeeds in realizing cooperative learning. For a course involving self-propelled toy-brick cars, there is little research on the application of low-grade pupils. Therefore, based on the integration of STEAM courses into self-propelled toy-brick car learning, this study applied two learning strategies of cooperative learning and individual learning to low-grade pupils in the second grade in elementary schools. After completing the course problem-solving ability indicators were measured and analyzed using the problem-solving ability test. The results show that the mean score of the experimental group in the problem-solving ability test was higher than that of the control group. In the problem-solving ability test, the scores of the two groups were also significantly different, which suggests that cooperative learning is more effective than individual learning strategies.

Keywords: STEAM, Problem solving, Self-propelled car, Cooperative learning.

1 Introduction

The 21st century is an era of rapid change and development, also known as an era of knowledge economy. In order to enhance the competitiveness of the country, talent cultivation is currently one of the topics that many countries attach great importance to. In 2009, US President Barack Obama launched the training of 100,000 STEAM teachers in the "10-Year Plan for Educational Innovation" policy [1]. STEAM education is now the key to cultivating scientifically and technologically innovative talents in the United States [2]. In addition, in the process of educational reform, pupils' creativity and practical ability are cultivated. Influenced by STEAM education in the United

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States and facing the pressure of intensifying global competition in science and technology, countries around the world have begun to actively promote STEAM education [3]. The importance of STEAM courses includes: starting from problems or situations, combining with real life situations, the programs and problem-solving abilities acquired by pupils can also be applied to the same or different situations in life [4]. It focuses on the learning process, and in addition to knowledge transfer, hands-on implementation and innovative thinking, the more important thing is the in-depth participation in the learning process and the enhancement of learning interest [5].

This study explored lower-grade elementary school pupils' problem-solving abilities when carrying out experiments after being subjected to STEAM courses making use of either cooperative learning or individual learning. We designed and planned cross-disciplinary STEAM courses and used self-propelled toy-brick cars to stimulate pupils to work independently. The content is related to life, thus arousing the curiosity to explore and apply knowledge in real-life. Pupils are thereby freer to explore, to learn, and to connect to real-life problems. Besides acquiring professional knowledge, pupils also learn skills in different fields that hopefully strengthen the perceived importance of science and technology. Pupils also learn teamwork, learn to be responsible for their own behaviors and cultivate professional attitudes and behaviors [6].

This study applied cross-disciplinary STEAM course teaching to two classes of second grade elementary school pupils to explore the effect of cooperative learning in contrast to individual learning on the effectiveness of their problem-solving abilities.

2 Related work

2.1 STEAM courses

STEAM courses integrate science, technology, engineering, mathematics, art, and other interdisciplinary courses [7]. It is a teaching method that emphasizes interdisciplinary cooperation. The purpose of STEAM education is to design and explore, and to solve problems using scientific and technological thinking. The design of course content, activities, and evaluation can be linked with the current development of science and technology or relevant experiences in real-life [8]. In the process working practically with their hands and cultivating problem-solving abilities, pupils are enabled to understand the interrelationships between various disciplines. STEAM can be defined as the education of improving pupils' interest in and understanding of science and technology, and the education of improving STEAM literacy based on science and technology and the ability to solve real world problems [9]. With the emphasis on education of science and technology in the United States, many science education policies and corresponding programs have followed. STEAM course integration relies on cooperative learning, science and technology teaching, exploring and learning courses and multiple assessment methods [10] to cultivate pupils' ability to use group cooperation, learn team cooperation, good communication skills and problem-solving skills. STEAM course integration adheres to the concept of pupil-centered teaching, emphasizes the connection with real social situations, and improves pupils' interest in science and technology by

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the process of actively constructing knowledge and learning integrated scientific knowledge and skills [11, 12].

In the learning process of STEAM education, emphasis is placed on hands-on, problem-solving and scheme-inquiry-oriented teaching, which can cultivate children's comprehensive abilities both internally and externally, including inquiry ability, critical thinking ability, creative thinking ability and problem-solving ability. Therefore, STEAM education can cultivate children's patience, willpower and frustration tolerance, and learn to be responsible for themselves [13].

2.2 Problem-solving ability

A problem is usually understood as the difference between current reality and expected goal [14], while problem solving involves the periodic interaction between cognition and action. Problem solving activities include defining the current and goal states, assessing a person's resources, identifying additional resource needs, identifying, constraining, and exploring basic assumptions that affect reasoning. When proposing models for systematic and critical reasoning, Paul [15] asserts that a fundamental element of problem definition involves deciding which conceptual elements to consider and which conceptual elements to exclude. As problems become more complex and structurally unreasonable, they are defined by interweaving technology and background elements. Considering the transformation process at the system and task levels, the latter is more inclusive by learning from the field of organizational research [16]. On the contrary, situational elements refer to the environment contained in these technological elements, including social, cultural, political, legal, ecological and economic characteristics [17].

In one's growth and development, there will be "problems" everywhere, which need to be "solved" from time to time. If we consider the "abilities" needed to deal with various problems together, we actually include "all abilities". We try to extract "representatives" of the abilities needed to deal with problems from all abilities (it may be only a part of all abilities, and is given an integrated name), and declare such ability as "problem-solving ability" [18].

2.3 Cooperative learning strategy

Nattiv [19] put forward that cooperative learning is a teaching method, in which pupils work together in groups and face common goals. Each member is individually responsible for learning, and "rely on each other" in terms of remuneration, work, materials and roles. The group members are usually heterogeneous in achievement, gender and race. Cooperative learning is a group teaching design which combines pedagogy, social psychology, group dynamics, etc. It mainly uses the division of labor and cooperation among group members to support each other and learn. In addition, group-based assessment and the social and psychological atmosphere of inter-group competitions are used to improve learning effectiveness. The purpose is to make learning activities into joint cooperative activities, and the success or failure of the learning activities is related to the honor or disgrace of the group.

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Therefore, cooperative learning has its own unique characteristics, which is different from other teaching methods. Cooperative learning is not as simple as placing pupils in groups to learn. More importantly, it involves organizing groups to promote cooperative learning within these groups. Cooperative learning is not just to let pupils sit around together and let each pupil do his or her homework. In a real cooperative learning group, members depend on each other, help each other, share resources, and promote each other's learning.

3 Method

3.1 Participants

The cohort in this study comprised second-grade pupils of an elementary school in Yunlin County. The pupils had not received any relevant STEAM education prior to this experiment. Therefore, the pupils were at the beginning stages of the STEAM courses. Two classes of second grade pupils were recruited to serve as the two groups in the experiment. There were 24 pupils in the experimental group learning STEAM courses with cooperative learning and there were 24 pupils in the control group learning STEAM courses with individual learning. The STEAM courses were offered to 48 pupils in total (see Figure 1). Each pupil was equipped with a set of STEAM self-propelled block cars and a remote controller, which could be used after the self-propelled block car had been assembled.

3.2 Assessment Tool - problem-solving ability test

The problem-solving ability test in this study refers to the previously revised problem-solving test, with the theoretical framework improved by Shiou-Mei Chan, Wu-Tien Wu, and the problem-solving ability assessment tool developed by redesigning the form, content and scoring method of the test according to the previous testing experience. After completing the STEAM courses, the learning strategies the two groups, namely the group exposed to group learning and the groups exposed to individual learning, were different.

3.3 Experimental process

This research experiment consisted of 24 classes taught over a period of 12 weeks. Each class lasted 40 minutes. In the first and second weeks of the experiment, the classes *STEAM Course-Understanding Building Blocks and Building Block Assembly* and *Grouping of Experimental Groups* were conducted to enable pupils to understand the car building block assembly and the way to build the blocks, which contained the fields of science, technology and engineering in STEAM education. This part took two weeks. In the 3rd week, the class *STEAM Course-Designing Your Own Car* was held to enable pupils to learn about the parts of the building block assembly car with what they learned

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about building block assembly. It covered the fields of science, technology and engineering in STEAM education course, which lasted for one week. In the 4th week, the class *STEAM Course-Program Warm Up* was held to enable pupils to understand the use of computers and what software to use to write the programs for the cars, which consisted of science, technology, engineering and mathematics and lasted for one week. The class *STEAM Course-Program Scratch Exercise* was held during the 5th week, with the purpose of letting pupils know how to arrange and write programs, and be familiar with the user interface and operation of the software, covering the fields of science, technology, engineering and mathematics and lasted for one week. On the 6th, 7th, 8th and 9th weeks, the class *STEAM Course-Program Scratch Practice-Building-Block Car Go Straight Forward, Turn, Go in Circle and Go Back* was conducted to let pupils know how to program and write programs, and learn how to write simple programs to control self-propelled cars, covering the fields of science, technology, engineering, art and mathematics for four weeks. The class *STEAM Course-Program Scratch Control Contest* was held during the 10th and 11th weeks. The two weeks were used to test the learning outcomes of the courses. Simple competition methods were used to understand what they have learned, including science, technology, engineering and mathematics, which lasted for two weeks. Week 12 was the last week. A *Problem Solving Ability* test was conducted to measure the effect of problem solving after completing the STEAM course. Data analyses were conducted immediately after the course ended.

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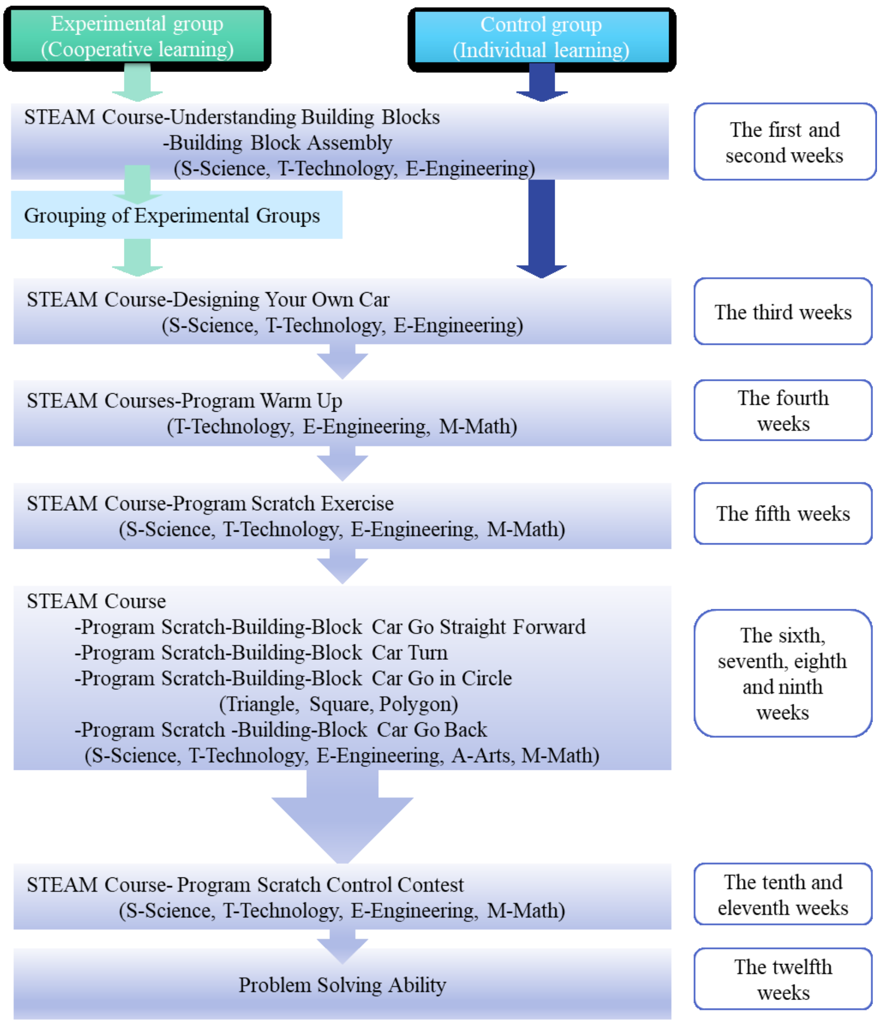

Fig. 1. Experimental process

3.4 Learning assistive

The participants used building blocks for Cosmos Robotics Company self-propelled cars to carry out building block assembly exercises. This series of the parts are shown in Figure 2. Figure 3 shows the remote controller and motor set used by the self-propelled toy car. DIY Transformable Building Block Car is a set of teaching tools that can train children's creative ability in manual work and logical thinking ability. The assembly process can stimulate different imagination and creativity among the participants. In addition to allowing subjects to practice assembling building blocks, the parts group also trains hand muscles, hand-eye coordination, and cultivates the habit of concentration. After the car is assembled, the remote controller can be used to control the

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car. In the practice of using the remote controller, one needs to know how to match one's own remote controller with the car and the control mode, which is the application of the ability of logical thinking and mathematical reasoning. After understanding the control mode of the remote controller, participants can start to practice programming to control the movement of the cars, produce solutions or new innovative ideas, to further develop and solve problems. Through the learning of building-block cars, participants could apply what they had learned into real-life and face the challenges in the future at a higher level.

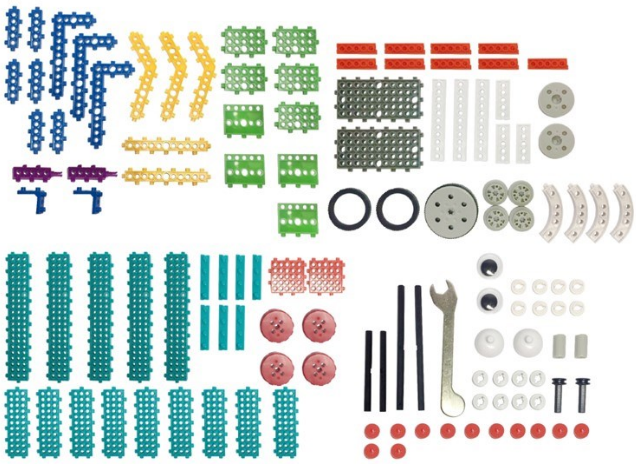

Fig. 2. The parts of D IY Transformable Building Block Car by Cosmos Robotics Company.

Fig. 3. The self-propelled car remote controller and moto.

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4 Results and Discussion

4.1 Problem-solving ability

Figure 4 shows the data visualized as a line chart of the test scores of pupils in the problem-solving ability test experimental group and the control group. One can observe that most pupils' scores in the experimental group are higher than those of the control group, and the final average scores, the average scores of the experimental group are also higher than those of the control group.

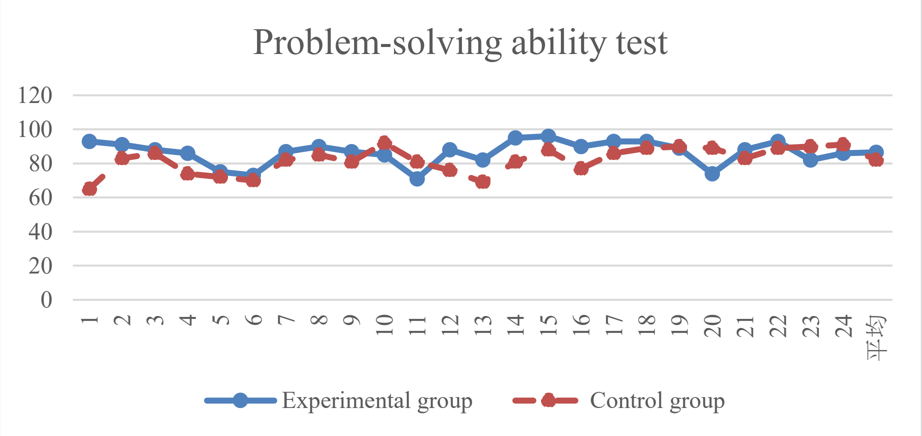

Fig. 4. Line chart of the test scores of pupils in the problem-solving ability test experimental group and the control group.

4.2 Problem-solving ability

After applying the STEAM course of building-block self-propelled car with cooperative learning and individual learning, the results of the learner's problem-solving ability tests were analyzed using an independent sample t-test. in order to understand the influence of learner's participation in the course on their problem-solving ability. The performances of the learner's problem-solving ability test were significantly different ($t(46) = 2.072$, $p = .44$) between the experimental group ($M = 86.46$, $SD = 7.05$) and the control group ($M = 82.04$, $SD = 7.70$). The results show that the learning strategies of cooperative learning have significant effect on problem solving after the learner has gone through the STEAM course of building-block self-propelled car in cooperative learning and self-directed learning.

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5 Conclusions and Future Work

The results suggest that the problem-solving ability of learners with the cooperative learning strategy yields higher problem-solving ability test scores than the independent learning strategy in context of a cross-disciplinary STEAM course involving building-block self-propelled cars. The STEAM education strategy combines the knowledge in five major fields of study, namely science, technology, engineering, art and mathematics through relevant courses to narrow the gap between different disciplines [20], and enables pupils to learn knowledge through multiple channels in different environments and project activities. The results of his study agrees with the effects advocated by STEAM education, namely improved cooperative learning, mutual discussion, communication in curriculum learning, and the improvement of problem-solving ability. It uses cross-disciplinary course learning and combines hands-on practice with innovative thinking inspiration, leading to the in-depth participation in the learning process and the promotion of learning interest. Learners' learning and absorption in the learning process can achieve better results when there is good interaction between learning methods and course learning in the learning process.

Future work includes in-depth discussion and analysis of the correlation of additional dimensions such as creative thinking, trial and errors and critical thinking.

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