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# Influences of a robotics creative project competition on students' scientific attitude and scientific inquiry abilities

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ABSTRACT: This study is based on the 2014-2015 First Lego League (FLL) competition, the Robotics Creative Project Competition with the subject named *World Class*, held by Lego. A total of 208 junior and senior high school students from 28 teams registered in this competition. The researchers interviewed the captain of each group and ten students from the first-placed team, in order to understand the participants' motivation, the difficulty of the preparation for the competition and what could be learnt from this competition. The study found that the Robotics Creative Project Competition could promote students' scientific attitude and boost their scientific inquiry abilities.

## INTRODUCTION

Nowadays, all walks of life and all levels of school are going all out to promote creativity, so all kinds of *technology competition* have become part of best practice. Every unit hopes that through competitions and problem-solving approaches validating a simple scientific principles, they can inspire students in this lively and fun way in order to promote teamwork and creativity and, therefore, achieve the purpose of creativity education [1]. During the time that students participate in the competition, in addition to participating in training to learn, their expertise and creative design indeed increase with time in the whole hands-on process. Therefore, in the final stage of such competitions, there will be the integration of new knowledge structures or new creative products [2].

The connotation of the competition may be the skills, knowledge, and even luck-oriented, etc, especially, when school students participate in creative competitions, they may sometimes display innovative and creative talents differently and more easily than in school life [3].

Yeh's study found that a non-standard educational environment usually have to design activities that can be operated in person or able to be explored to attract students to participate in the course [4]. Providing students with education different from that received at school can make students strive harder. In the process of educational training, preliminaries, and the finals, students can participate in the activities they are interested in, and it creates an environment for students to discuss and negotiate with each other. These events enhance the opportunities for students to discuss and for thinking. However, research about the motivation for competitions have found that the subjects of this type of research in Taiwan are typically students from elementary to senior high schools, and the fields are mostly sports competitions, while science and creative design competitions occur less often [5].

Many studies have shown that hands-on activities can promote students' motivation to learn science, and can effectively improve students' scientific attitudes [6-8]. Although there might be a gap between the situation where students are engaged in scientific activities and the scientific work, which scientists are doing, it is a highly instructive experience. Exploration in laboratories or hands-on activities improve the comprehension of scientific concepts better than when students are acquiring fragmented knowledge or memorising facts [9][10].

## LITERATURE REVIEW

### The Robotics Creative Project Competition

The Robotics Creative Project Competition has become very popular in recent years because the competition can provide students with an environment in which to study science, technology, engineering and mathematics (STEM)

[11][12]. Riley and Karnes found that competition allows students to get more benefits, such as independent study, more confidence, increasing capacity, methods of crisis management, thinking diversity, adventurous spirit and flexible and creative ideas, etc [13].

Petre and Price conducted semi-interviews with several robot competition contestants and coaches, and found that the actual operations of a robot can indeed guide students to understanding the principles of program design and engineering [14]. By holding the Lego robotic camp, Williams et al conducted a mixed-research project about the influence a Lego robot has on the scientific inquiry and knowledge of physics among high school students [15]. They found that it really has a great effect on both of them. Using an autonomous robot in both formal and informal learning environments can improve learning in mathematics and science, and can also enhance critical thinking and problem-solving skills [16]. Chung et al study showed that a STEM robotics competition can improve learning outcomes [12].

A study by Shieh and Wheijen shows that hands-on activities, and trial and error learning experiences not only help students enhance their creativity and problem-solving skills, but also they help students to comprehend the value of cooperation [17]. The First Lego League (FLL) held by Lego is a very popular competition. The competition is divided into *Project*, *Robot Game*, *Robot Structure* and *Core Values*. The theme of the 2014-2015 FLL competition was *World Class*. Participating students had to team up with the theme, *World Class*, and utilise Lego mind storms to simulate the project's productions. The FFL is a competition emphasising teamwork, problem-solving ability, creativity, scientific literacy and IT capability.

Scientific Attitude

Scientific attitude has been emphasised for decades in science education [18]. The main purpose of science education is to enhance a nation's scientific literacy, and strengthening students' scientific attitude is one of the key points. Scientific attitude and interest provide the momentum to maintain science learning [19]. When students' scientific attitude is enhanced, not only will good learning outcomes be produced, but also the future of learning activities will be promoted. Recently most science education researchers have adopted Gardner's distinction about scientific attitude [20].

According to Gardner's definition, if the tendency of an individual action involves more personal scientific knowledge and faith, and more cognitive part, it is called SA (scientific attitudes). On the other hand, if the individual's evaluation for science in scientific learning involves more personal emotional reactions, and more inclined part, it is called ATS (attitudes toward science) [8][21-23].

Johnson et al proposed that hands-on activities could effectively improve student attitudes toward science [6]. Chang et al investigated the scientific attitude of students participating in a commentary event through semi-structured interviews, and found that the students' scientific attitude had improved [22]. Lin et al used quasi-experimental design and developed teaching materials about learning friction by using the 5E teaching model combined with scientific magic [8]. Research found that it is effective and can enhance students' attitudes toward science.

Wen-jin et al pointed out that hands-on activities can promote students' motivation to learn science, and hands-on topics related to life events can promote students' motivation to learn science better than other activities [7]. Lin et al believed that well-designed learning activities are effective in attracting students' attention and promoting their learning [8]. Moreover, if teachers provide students with enough time to operate activities materials, it is more likely that students can develop a positive science attitude.

Scientific Inquiry Abilities

Scientific inquiry including a series of activities is the process that scientists use to explore the natural world and construct scientific concepts and knowledge. Developing students' cognition and ability towards scientific inquiry is the core of science learning [24].

Liu and Chang mentioned that although there might be a gap between the situation through which students are going when engaged in scientific activities and the scientific work that scientists are doing, it is a highly instructive experience that a science teaching without student experiments and exploration cannot beat [10]. Pai and Hsu indicated that more opportunities should be provided for students to do hands-on activities in the laboratory or in the exploration activities in order to promote their understanding of scientific concepts rather than fragmented memorisation of knowledge and facts [9].

Foster and Lemus found that creative exercises in scientific inquiry helped improve students' science skills and build up students' confidence when describing and assessing scientific questions [24]. Chen and She conducted a teaching experiment in a scientific inquiry project focusing on scientific deduction [25]. Results indicated that the experimental group outperformed the control group, regardless of scientific concept tests, scientific concept-dependent reasoning tests and scientific inquiry tests. Moreover, the experimental group also did better on the class scientific worksheet than the control group.

## RESEARCH METHOD

### Research Procedures

In this study, researchers should understand the influences of the robotics creative project competition on student's scientific attitude and scientific inquiry abilities. The Robotics Creative Project Competition was held in cooperation with the 2014-2015 First Lego League (FLL) held by Lego. The Competition was divided into *Project* and *Robot Game* with the subject, *World Class*. Participating students completed scientific attitude and scientific inquiry abilities pre-tests on a Web registration system at the time of registration and, then, prepared for the competition for two months. All participating students filled in scientific attitude and the scientific inquiry abilities post-tests on the day of the competition. The scores for scientific attitude scale and scientific inquiry abilities scale were collated for analysis. The extracted data were analysed using paired *t*-tests and SPSS version 17.0. In addition, the researchers interviewed captains of every group and ten students from the winning team, in order to understand the participants' motivation, the difficulty of preparing for the competition and what they got from the competition.

### Participants

The sample consisted of a total of 208 students in 28 teams. There were 66 junior high school students and 142 senior high school students.

### Instruments

*The Scientific Attitude Scale*: the scientific attitude scale refers to Huang's development of the science-related attitude scale [26]. After the questionnaire was developed, five scholars and experts were invited to determine the content validity of the questionnaire. After some modifications had been made, the official questionnaire was finalised. A five-point Likert scale was employed in the questionnaire, containing four domains: attitude to participate in the activities of scientific inquiry (9 items), attitude toward science (7 items), learning scientific attitude (5 items) and attitude during scientific activities (5 items). Then, 250 questionnaires were distributed; 239 valid questionnaires were returned (95.6% of return rate). The results of the reliability test indicated that it was very reliable. The science attitudes scale included: the Cronbach α of the total scale and sub-scales are 0.972, 0.950, 0.892, 0.837 and 0.849. All items were loaded with a factor loading over 0.40.

*The Scientific Inquiry Abilities Scale:* the scientific inquiry abilities scale refers to Su's development of the scientific inquiry abilities scale [27]. After the questionnaire was developed, five scholars and experts were invited to determine the content validity of the questionnaire. After some modifications had been made, the official questionnaire was finalised. A five-point Likert scale was employed in the questionnaire, containing four domains: problems found (3 items), collection of information (5 items), implementing operation (4items) and implementing design (3 items). Then, 250 questionnaires were distributed; 238 valid questionnaires were returned (95.2% of return rate). The results of the reliability test indicated that it was very reliable. the science attitudes scale included: the Cronbach α of the total scale and sub-scales are 0.915, 0.708, 0.759, 0.834 and 0.874. All items were loaded with a factor loading over 0.40.

## FINDINGS

After the study was completed, the results of the survey questionnaires were analysed using paired *t*-test in SPSS 17.0 statistical software. The attitudes to science and scientific inquiry abilities expressed by participating students showed a marked improvement after the Robotics Creative Project Competition. The paired *t*-test analysis results indicated significant differences between the post-test's means (107.01) and pre-test's means (116.70) on the science attitudes scale ($t$ = -6.643, p = 0.000). According to the sub-scales of the science attitude scale, the scores were also analysed. The results showed that the post-test's score was higher than that in the pre-test in each sub-scale.

The mean scores of the scientific inquiry abilities in the pre-test and post-test were 60.38 and 62.98, respectively. The paired *t*-test analysis results indicated significant differences between the post-test and pre-test means on the scientific inquiry abilities ($t$ = -2.804, p = 0.014). Scores according to the sub-scales of the scientific inquiry abilities scale were also analysed. The results showed that the post-test scores were higher than the pre-test scores for three domains: problems found, collection of information and implementing design.

Table1. The paired *t*-test analysis of student's scientific attitude.

| Scale | Pre-test | | Post-test | | *t* value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Attitudes toward science | 27.76 | 3.150 | 28.74 | 3.594 | -2.454* |
| Learning scientific attitude | 21.49 | 2.728 | 26.74 | 3.176 | -14.410*** |
| Attitude to participate in the activities of scientific inquiry | 37.59 | 5.463 | 39.50 | 4.896 | -3.191** |
| Attitude when scientific activities undertaken | 20.17 | 3.240 | 21.72 | 2.845 | -4.469*** |
| Total scale | 107.01 | 12.986 | 116.70 | 13.077 | -6.643*** |

Note: N = 208; *p < 0.05, **p < 0.01, ***p < 0.001

Table2. The paired *t*-test analysis of student's scientific inquiry abilities.

| Scale | Pre-test | | Post-test | | *t* value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Problems found | 11.84 | 1.686 | 12.30 | 1.752 | -2.089* |
| Collection of information | 20.28 | 3.156 | 21.43 | 2.731 | -3.199** |
| Implementing design | 12.35 | 2.186 | 13.20 | 1.882 | -3.376** |
| Implementing operation | 15.91 | 2.780 | 16.04 | 2.721 | -.396 |
| Total scale | 60.38 | 8.544 | 62.98 | 7.105 | -2.804** |

Note: N = 208; *p < 0.05, **p < 0.01

## DISCUSSION

The paired *t*-test analysis results indicated statistically significant differences between the post-test and pre-test means on the science attitudes scale and the scientific inquiry abilities scale. Analysis of the scores according to the sub-scales of the science attitude scale and the scientific inquiry abilities scale was also undertaken. The results showed that the post-test scores were higher than the pre-test scores on each sub-scale in the science attitude scale. Meanwhile, the post-test score was higher than the pre-test score on the aspects of problems finding, collection of information and implementing design in the scientific inquiry abilities scale. It can be seen that participating in the Robotics Creative Project Competition can promote students' scientific attitude and scientific inquiry abilities.

The result that students' scientific attitude and scientific inquiry ability was significantly improved is reasonable and matched results from many other studies. To undertake the *Project* and *Robot Game* students needed to go through a long period of gathering information, holding group discussions, implementing testing, problem-solving and aggregating outcomes, etc [6][7][9][15][26].

Hands-on activities can promote students' motivation to learn science, and those relating to life issues can promote students' motivation to learn science better than other activities, and can effectively improve their attitudes to science. It would be helpful to promote students' understanding of scientific concepts and scientific inquiry ability by providing more opportunities for them be involved in hands-on activities in the laboratory or in exploration activities.

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