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Developing the Creative Cane Designing STEM Education Unit for Grade 6 Thai Students

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Abstract: The study aimed to clarify the development of the creative cane designing STEM education unit for Grade 6 Thai students. The sample group consisted of 17 Grade 6 students in Ban Noen-Rang Wittayakarn School, under the Office of Khon Kaen Primary Educational Service Area l, who were selected through a cluster random sampling during the second semester of academic year 2017. Methodology was the quantitative research. The pretest and protest design was applied in order to validate the quality of the creative cane designing STEM Education unit. The study was to compare pretest and posttest about student achievement on science learning, critical thinking ability and attitude toward STEM unit. The research instruments included instructional set of the creative cane designing STEM Education unit, achievement test on science learning, critical thinking ability test, and questionnaire on attitude toward STEM unit. Data analysis was descriptive analysis. The mean, standard deviation, and t-test were computed in order to provide comparison of pretest and posttest about student achievement on science learning, critical thinking ability and attitude toward STEM unit. The results indicated that the creative cane designing STEM Education unit was good quality. The efficiency of the creative cane designing STEM Education unit passed criterion of E1: 80 and E2: 80. It revealed that the mean for efficiency of process (E1) was 82.94. And, the mean for efficiency of product (E2) was 81.18. It indicated that the students' mean of pretest and posttest on science learning achievement have been significantly (.01) different. The students' mean of pretest and posttest on critical thinking ability have been significantly (.01) different. The students' mean of pretest and posttest on attitude towards STEM unit have been significantly (.01) different. This study has implications for developing STEM education unit in primary school.

Keywords: STEM education, cane, critical thinking, attitude, materials, force and motion, electronics

1. Introduction

Students in the twenty-first century must be successful in the effective workforce. Thus, greater education and a focus on various life skills, workforce skills, applied skills, personal skills (curiosity, imagination, critical thinking, and problem-solving), interpersonal skills (cooperation and teamwork) tend to engage students to be a well-educated citizen (Suparee and Yuenyong, 2021). These appropriated skills are also known as higher-order thinking skills, deeper learning outcomes, complex thinking and communication skills, and so on. Some skills are improved in students' learning based on a problem-based learning approach, particularly basic problems in their local community that lead students to become fundamentally aware. Indonesia implemented STEM and problem-based learning to provide students with STEM literacy in order to improve student achievement of previous skills and integrate science and mathematics (Masita et.al., 2021; Suwono et.al., 2022).

The Thai society had been dynamically and continuously transformed from the ancient age to the agricultural age until it entered the age of industrial change where machines were used to replace animal and human labor, then social behavior had been alter again when it entered the information age, or the so-called Thailand 4.0. It is an age of technology and innovation in which information can be found readily (Charnprasert, 2014). In such challenging situation it is therefore necessary to help the learners to develop to a higher degree of desired capability. To attempt to meet the challenge it is also necessary to have more teachers who have higher skills in the learning activity management, to have a positive attitude towards teaching profession and strong motivation, especially for the 21st century. It’s the kind of skill needed for a brighter future which teachers ought to possess in order to be able to innovate new ways of managing classrooms for the continuous and sustained development of youth of the new age. This is in accordance with the Nation’s 20-year Development Strategy (2017-2036). It is also in line with the principles of Educational Administration Act of 1999, (2nd revision, 2003 and 3rd revision, 2010) in which Article 22 stipulates that to manage education the persons concerned will have to uphold the principle of the learner’s ability to learn and to develop themselves and that the learners are the most significant person in the learning activities (Gerdwibulvej, 2014). Therefore, to manage education for the present age will need to focus helping the learners to develop naturally and to the fullest of their potentiality. This is in line with the Creativity-Based Learning or the CBL that emphasizes student-centered learning activities in which the students are encouraged to learn by themselves and to apply what they have learned to innovating new things. The Creativity-Based Learning Activity was adapted from Problem-Based Learning in which the teachers switch their role from a transmitter of knowledge to that of a demonstrator or facilitator. The teachers allow the students to develop learning skill, to motivate learning and to create a suitable learning atmosphere. In addition, the policy of The Ministry of Education that stipulate “decreasing studying time to increase learning time” emphasizes the important aims of developing the learners to meet the learning standards and skills for the 21st century. It opens up opportunity for the learners to build up a body of knowledge and skills by themselves in the manner of active learning through actual practice, high thinking level and varied team-work activities (Han et al, 2015; Wongsila and Yuenyong, 2019a; Wongsila and Yuenyong, 2019b; Yuenyong, 2019).

The management of learning science activities for the students at Noen-Rang Wittayakarn School is for the students to do testing practice in accordance with the subject contents. Nevertheless, some of the students fail to interest in the activities as these cannot be applied to their daily life. Besides, the testing steps as stipulated in the text allow very little room for the students to develop their thinking skill and hence make it impossible for them to achieve a well-rounded development. Furthermore, the national assessment of students’ learning achievement for years 2015 and 2016 revealed that the students made a mean of 38.36 and 34.92 in Science, and made a mean of 35.28 and 35.00 in Mathematics which are much below the passing criterion of 50 (The National Educational Testing Institute, 2015-2016). It is evident from the statistics that the students' low achievement in the two subjects is a rather grave problem that needs immediate solution. As our research team has been entrusted with looking after the development of special education that has been offered by universities and schools to assist those students who are in need of special care, we have decided to organize learning activities on the subject of electricity with a genius cane being an integral part of the study. STEM Education that integrates subject content with scientific, mathematics, engineering and technological skills to make an effective learning arrangement has presently been widely acclaimed. There have been research studies that attest to this achievement (Jannang, 2013; Julawatanatol, 2013; Riang-narong, 2015; Sutaphan and Yuenyong, 2019).

The four subjects in the STEM Education truly contribute to the learners the knowledge and the ability to live an effective life in the 21st Century which is continually changing, and societies are based on knowledge and technology which continue to keep moving forwards endlessly. In the past, the learning of Science, Mathematics and Technology was organized into separate, independent subjects. Each subject was organized in such a way that its content was arranged into orderly tiers making it impossible for the subjects to merge with each other, thus there have been trends to integrate engineering process skill with instructional and learning activities to make learning in Science, Mathematics and Technology more interesting as well as effective (Thananuwong, 2013). The research team has been led by the foregoing rationale to apply the creative-based learning together with STEM Education Approach to organize learning activities for the development of the learners to meet the goals of the B.E. 2551 core basic education curriculum (Sutaphan and Yuenyong, 2019; Tupsai et.al., 2019). Our past teaching experience shows that it is highly possible to help the learners to become well-rounded through creativity-based learning activities. In addition, learning activities basing on STEM Education Approach will enable the learners to combine their knowledge with the scientific, mathematics, engineering and technological skills for solving problems and to create innovations and or a new body of knowledge. The learning so organized will also promote the students' critical thinking ability and positive attitude towards learning and higher learning achievement. The members of the present research team, being responsible for instructing the curriculum and instruction courses and special education program, therefore desire to reinforce their teaching capability so as to fit in with the role of a teacher of the 21st Century by constructing a creativity-based instructional set entitled The Genius Cane, based on STEM Education Approach, for the development of learning achievement, critical thinking and positive attitude towards learning of Grade 6 students. The study aimed to develop the creative cane designing STEM Education unit and validate the unit through students' learning outcomes. The conceptual framework of the study was developed based on the figure 1. The validation of the STEM education unit, therefore, could evaluate through the development of student achievement on science learning, critical thinking ability and attitude toward STEM unit.

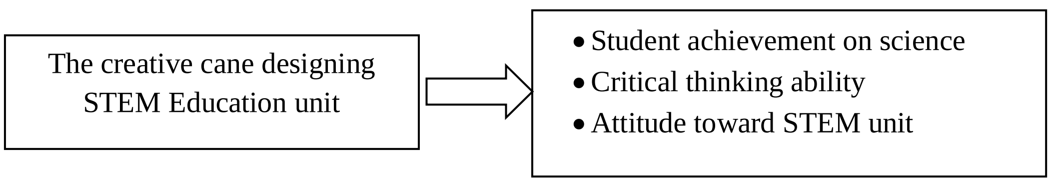

Figure 1: Conceptual framework of developing the Cane STEM education unit

2. Methodology

Methodology was the quantitative research. The pretest and protest design was applied in order to validate the quality of the creative cane designing STEM Education unit. The study was to compare pretest and posttest about student achievement on science learning, critical thinking ability and attitude toward STEM unit.

2.1 The hypothesis of the study

The hypothesis of the study was provided as below:

- The efficiency of the STEM unit passed criterion of E1: 80 and E2: 80 when E1 referred to the mean for efficiency of process and E2 referred to mean for efficiency of product.
- The students' mean of pretest and posttest on science learning achievement have been significantly (.01) different.
- The students' mean of pretest and posttest on critical thinking ability have been significantly (.01) different.
- The students' mean of pretest and posttest on attitude towards STEM unit have been significantly (.01) different.

2.2 Population and samples

Population included Grade 6 students in the 45 educational opportunity extension schools under the Office of Khon Kaen Primary Educational Service Area 1 during the second semester of the 2017 academic year.

Samples included 17 Grade 6 students in Ban Noen-Rang Wittayakarn School, under the Office of Khon Kaen Primary Educational Service Area 1, who were selected through Cluster Random Sampling during the second semester of academic year 2017

2.3 Research instruments

In order to validate the quality of the creative cane designing STEM Education unit, the research instruments included instructional set of the creative cane designing STEM Education unit, achievement test on science learning, critical thinking ability test, and questionnaire on attitude toward STEM unit.

2.3.1 Instructional set of the creative cane designing STEM Education unit consists of teaching materials for teachers and learning materials for students. Materials for teachers included (1) the important content of the instructional set, (2) purposes of instruction, (3) instructional method, (4) instructional media/learning resources, (5) measurement and evaluation and (6) suggested activities. Materials for students included (1) the situation sheet, (2) the purposes of instructional set, (3) instructional media, (4) knowledge sheet, (5) work sheets and (6) tests and questionnaires.

2.3.2 Achievement test on science learning consists of two types of the 4 choice items test in order to examine students' learning about materials, force and motion, electric circuit and capacity, and electronics and sensors. These included the test for efficiency of process (E1) and test for efficiency of product (E2). In order to provide the E1, the five sub-unit tests were provided including test on materials, test on force and motion, test on electric circuit and capacity, and test on electronics and sensors. Each of five tests is the 5 items of multiple choices test. And, test for efficiency of product (E2) was a 30 items summative test on materials, force and motion, electric circuit and capacity, and electronics and sensors.

2.3.3 The critical thinking test is the 20 items of multiple choices in order to assess students' ability to evaluate given information and make a decision using a variety of logical skills. The test is designed in such a way that students must examine the evidence presented and decide on the strength of the arguments related to develop prototypes and framework of testing prototypes about a smart cane.

2.3.4 Questionnaire on attitude toward STEM unit, dimensions of students' attitudes toward STEM unit studied based on predetermined indicators, namely the social implications of STEM, attitudes toward scientific and mathematical investigation, attitudes toward practicing knowledge for making a prototype, and enjoyment in learning STEM. A Likert scale was used to assess the attitudes of STEM students in this study. Likert scale provided type of scale including strongly agree (SA), agree (A), doubt (R), disagree (D), and strongly disagree (DS). Each positive item on the instrument has a value: SA = 5, A = 4, R = 3, D = 2, and DS = 1. The score is reversed for negative items.

2.4 Data collection

Data collection was managed in the following steps during the second semester of the 2017 academic year. Data collection for instructional set of the creative cane designing STEM Education unit, achievement test on science learning, critical thinking ability test, and questionnaire on attitude toward STEM unit was clarified as follows.

l) To find the effectiveness of the instructional set in accordance with the 80/80 criterion (1:1 for individuals, 1:10 for group; and 1:30 for field collection);

2) To administer a pre-test on learning achievement in science and critical thinking ability and a questionnaire to test the students' attitude towards learning activities.

3) To conduct learning activities for the sample group by following the instructional set for 6 weeks.

4) To conduct learning achievement in science and a critical thinking ability tests and to ask the student sample group to answer the questionnaire for testing their attitude towards the learning activities.

2.5 Data analysis

Data analysis was descriptive analysis. The mean, standard deviation, and t-test were computed in order to provide comparison of pretest and posttest about student achievement on science learning, critical thinking ability and attitude toward STEM unit.

3. Results

The results will be presented into three sections. These included 1) efficiency of the creative cane designing STEM Education unit, 2) comparison of students' mean score of pretest and posttest on science learning achievement, 3) comparison of students' mean of pretest and posttest on critical thinking ability, and 4) comparison of students' mean of pretest and posttest on attitude towards STEM unit.

3.1 Efficiency of the Creative Cane Designing STEM Education Unit

It indicated that the efficiency of the creative cane designing STEM Education unit passed criterion of E1: 80 and E2: 80 when E1 referred to the mean for efficiency of process and E2 referred to mean for efficiency of product.

Table 1: Efficiency criterion for instructional set

Instructional Set	80/80 criterion	
	E_1	E_2
Creative Cane Designing STEM Education Unit for Grade 6 Students	82.94	81.18

According to the table 1, it revealed that the mean for efficiency of process (E1) was 82.94. And, the mean for efficiency of product (E2) was 81.18. It indicated that the creative cane designing STEM Education unit was good quality. This could be interpreted that the unit was well developed.

3.2 Comparison of students' mean of pretest and posttest on science learning achievement

According to the table 2, the mean of pretest on science learning achievement was 10.41. And, the mean of posttest on science learning achievement was 16.24. It indicated that the students' mean of pretest and posttest on science learning achievement have been significantly (.01) different.

Table 2: Students' mean of pretest and posttest on science learning achievement

The testing	n	$\bar{X}$	S			t
Pretest	17	10.41	1.37	99	605	18.00**
Posttest	17	16.24	1.15			

**Significantly different at .01 level

3.3 Comparison of students' mean of pretest and posttest on critical thinking ability

According to the table 3, the mean of pretest on critical thinking ability was 10.29. And, the mean of posttest on critical thinking ability was 14.18. It indicated that the students' mean of pretest and posttest on critical thinking ability have been significantly (.01) different.

Table 3: students' mean of pretest and posttest on critical thinking ability

The testing	n	$\bar{X}$	S			t
Pretest	17	10.29	2.76	66	310	8.732**
Posttest	17	14.18	2.53			

**Significantly different at .01 level

3.4 Comparison of students' mean of pretest and posttest on attitude towards STEM unit

According to the table 4, the mean of pretest on attitude towards STEM unit was 2.18. And, the mean of posttest on attitude towards STEM unit was 4.44. It indicated that the students' mean of pretest and posttest on attitude towards STEM unit have been significantly (.01) different.

Table 4: students' mean of pretest and posttest on attitude towards STEM unit

The testing	n	$\bar{X}$	S			t
Pretest	17	2.81	0.16	27.55	45.28	33.67**
Posttest	17	4.44	0.29			

**Significantly different at .01 level

4. Conclusion and discussion

The first phase of the research study was for the development of the creative cane designing STEM Education unit for Grade 6 students, and the set was given the title of creative cane designing. The second phase of the study involved a trying out of the instructional set that had been developed, the results of which were reported that there were significantly (.01) different mean score among pretest and posttest on science learning achievement, critical thinking ability, and attitude towards STEM unit

It indicated that the creative cane designing STEM Education unit was good quality. The creative cane designing STEM Education unit was developed based on Sutaphan and Yuenyong (2019) STEM education teaching approach. The learning activities were provided through 7 stages including 1) identification of social issues, 2) identification of potential solutions, 3) need for knowledge, 4) decision making, 5) developing prototypes or products, 6) testing prototypes or products, and 7) socialization and completing products.

Identification of social issues stage, the learning activity engaged students through the video about elderly or disability people with walking aid tools (e.g. sticks, cane, mobility aids, etc.). The classroom, then, allowed students to share ideas about what the best walking cane should be look like.

Identification of potential solutions stage, the activities provided students to list the possible solutions. Students were asked to select their target users and then list the possible needs of those users. Students may survey what kinds of people and age will use a cane. They may also to collect data about what the users need for a cane. Students may carry out their research about the need of cane users via asking a questionnaire. These questions would be asked 1) Age and gender 2) Have you ever used a cane? 3) From your experience using the cane, is there anything that needs improving? 4) In your opinion, how important is walking devices (walker, crutch, wheel chair) to Elderly? 5) In your opinion, how important is cane to Elderly? 6) Have you been hospitalized in the past 10 years? 7) Do you have difficulties with activities listed in the following? (Eating, Bathing, Dressing, Toilet use, Walking inside and outside the house, meal preparation, ordinary housework, shopping) 8) Do you habitually hold onto furniture/railings for balance while walking at home? 9) What influence you when purchasing a cane? 10) Under what circumstance will (did) you start using a walking stick/cane? (Wong and Yang, 2018). Then, students also asked to share their initially design the cane – how they could design, what they would know for designing a cane, and so on. The classroom sharing ideas may suggest some need for knowledge. That knowledge may include materials for a cane, user weight and motion, friction forces, knowledge about electronic and sensors for case of a smart cane, and so on.

Need for knowledge stage, this stage provided students' knowledge that probably was needed for their practicing when they design a cane. Arefin et.al. (2020) suggested some knowledge that related to design a cane. These included kinds of cane, materials, force and motion, electronic, and sensors.

- Learning activities introduce the kinds of cane. The different kinds of cane (e.g. regular canes, canes offset, and quad-canes) were introduced to students. The ergonomics handle design also should be addressed. Canes with ergonomic handle designs are walking sticks with handles that provide more significant support to the user and reduce the risk of wrist injury. Ergonomic canes are made with the goal of providing comfort, style, and durability. The handles are comfortable to hold and reduce wrist stress, making them ideal for cane users (Sudarsky, 1990; Van Hook, 2003).
- Learning activities about materials, classifying materials and its properties were provided. Students design kinds of materials that appropriate each part of cane. For examples, the shaft shape varies depending on the type of cane used. Grips come in a variety of sizes and shapes. The best type of handle to use depends on whether the system is being used to support the user's weight or to help them maintain their balance. Ferrules in walking canes are typically made of rubber and are only a few inches thick. They are used to increase the device's stability and improve the contact grip between it and the ground. The cane shaft connects the ferrule to the handle and is typically made of wood or aluminum, with an emphasis on lightweight design. Depending on personal preferences, the handle material can range from wood to ABS plastic.

- The unit also provided experiment about force and motion in order to suggest students what factors (e.g. weight, net forces, directions of forces, friction forces) influence to the motions of people with a cane. Then, students could practice knowledge about force and motion for weight of cane. Smart canes are outfitted with devices that can reliably calculate weight and cane load. Walking canes should be lighter for this purpose. It should be heavy enough to support the user's weight while also being as light as possible to be user friendly. The popularity of walking sticks on the market suggests that the weight of walking canes is one of the most important factors to consider when deciding which one to use. (Alexander, 1996; O'Sullivan and Schmitz, 2001)
- Learning activities about electronics and sensors was provided in order to support students design power capacity and management, and types of sensors. Students did the experiment about static electric circuit which they could construct meaning of voltage, current, resistors in close circuit. Students were introduced to know type of sensors. These, for examples, included sensors about detecting a possible obstruction in the user's way, sensor for tracking cane, and so on.

Decision making stage, students developed justifications for selecting a kind of cane and sensors for smart cane.

Developing prototypes or products and testing prototypes or products, the unit provided the below list in order to scaffold students to develop prototypes and framework of testing prototypes.

- Students have to find materials that appropriate each part of cane and concerning with the weight of walking canes that market suggested.
- Students design capacity. They may find the input voltage should be between 9V and 12V DC, and the current must be rated for a minimum of 250mA current output, although something more like 500mA or 1A output is better.
- Design the power management that students have to optimize battery life to fit to essential aspect of their types of smart canes with minimal computing capabilities.
- Students prepare the workflow of developing prototypes. And, they have to plan about what kinds of job should be helped by experts.

Socialization and completion decision, Students presented their prototypes or products that related to the cane to the committee. Each group explained what their final product is and how they developed and tested their product. The committee reflection, then, allowed students to revise and optimized their prototypes and completion.

This study has implications for developing STEM education unit in primary school. The study revealed that how making a thing could motivate students to practice the integrate knowledge for creative problem solving. The STEM education unit could foster students to solve problems in real life situations (Bataluna et.al., 2021; Masita et.al., 2021; Thi Thuan and Nguyen Mau, 2021). These learning activities are in line with learning in the 21st century that can be linked to daily life. In addition, learning management in accordance with STEM Education Approach is actually an integration of science, technology, engineering and mathematics to challenge the learners' capability and interest in learning through participation in the activities as organized by the research team.

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