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Developing Critical Thinking of Grade 10 Students through Inquiry-Based STEM Learning

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Peeradon Onsee[1] & Prasart Nuangchalerm[2*]

[1,2]Department of Curriculum and Instruction, Faculty of Education,
Mahasarakham University, Mahasarakham, Thailand
Corresponding Author: *prasart.n@msu.ac.th

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Abstract

Thematic approach in education is a way of holistic view in modern instructional practices. The 21st century learning needs students have ability and necessary skills, especially thinking critically than content focused. This action research aims to enhance critical thinking and learning achievement of grade 10 students through inquiry-based STEM learning. Twenty first students were participated by who had mean score lower than 70 percent of critical thinking. The research instruments consisted of 6 lesson plans, 20 items of critical thinking test with 4-multiple choice, interviewing form in teaching and learning environments, and observation during lesson plans implementation. Data were gathered and analyzed by descriptive statistics. The result showed that students who learned through inquiry-based STEM learning can increase their critical thinking to meet the criterion. Qualitative data indicated that they need more improvement in the diversity of learning methods as well as STEM education. Suggestion needs students to design and criticize in their working assignment.

Keywords*:* Critical Thinking, Inquiry, STEM Education, Integrated Learning, Action Research

INTRODUCTION

Teaching and learning in a new era seems to be different, teachers and students need to aware of current information. Online information seems to be reliable and unreliable. Students have to access in a variety of sources, and making suitable decisions on reliable information. Teachers also make the pedagogical decision making to improve learning outcomes to reach the goals of education (Prachagool et.al., 2016). In school science, students are allowed to learn in both contents and process of science. Curriculum and standards recognized them to have learning competency as well as necessary learning skills must be promoted (Chalkiadaki, 2018). Products of science produce too many knowledge through scientific research and publications. Students can gain their much more knowledge and understanding by the product of science, even though process of science helps them to think and do as scientists (Nuangchalerm, 2009; Nuangchalerm & Prachagool, 2019; Prachagool & Nuangchalerm, 2019).

Critical thinking is often listed as the most important skills for students in 21st century. It is a vital topic in modern education in order to success in life and career at present (Marin & Halpern, 2011). Due to, critical thinking helps students make their own question to phenomena, plan and design process to seek answer, searching for related information, think critically in the findings, conclude and make final decisions (Duran & Sendang, 2012). Therefore, today the world is in the variant of information and diversity of knowledge. Critical thinking is the one of necessary learning skills for new youngers (Wartono et.al., 2018). It is the foundation of thinking, but it needs more to incubate for students than the previous era. Especially, science and pseudo-science are growing in rapidly in the age of online information transforming (Dostál et.al., 2018).

Now a day, students need more necessary skills to deal with new information technology and to effectively communicate with any resources. Then they have to give reasoning to be attentive, creative, and efficient (Polyiem et.al., 2011). The critical thinking has to cultivate on student as soon as possible since school (Ismail et.al., 2018). To teach students in such skill, learning process need to be different such as more flexible, creative, actively engaged and more challenging will be required. As the present in school, new curriculum allows learning activities to gain more experiences and thinking skills through thematic approaches. At the root of belief of

growing, students have to learn through thinking and doing by suitable lesson, mapping knowledge to daily lives, thinking as integration, and living in critically (Wechsler et.al., 2018).

In fact, critical thinking cannot be appeared if the students do not response to situations. They get some passive learning and ignore to critically stimuli. Learning experiences are importance to them in improving critical thinking. Thematic approach as we known, STEM education is an importance candidate to improve critical thinking by many reports (Wilson & Mack, 2014: Erdogan & Stuessy, 2015; Han et.al., 2015; Hurst, 2015; Xie et.al., 2015; Hackling, 2016; Storksdieck, 2016; Zeidler, 2016; English, 2017; Shahali, 2017; Lai, 2018; Mutakinati e.al., 2018; Ring-Whalen et.al., 2018; Toma & Greca, 2018). STEM education is an approach to educate students in four specific disciplines; science, technology, engineering and mathematics and allow to apply their knowledge for real life problem (Bybee, 2010). Moreover, students have to establish their own knowledge by thinking, planning, designing, searching, communicating, discussing, and presenting of what they had learned about learning innovation (Listiana et.al., 2019).

STEM education is an integration of 4 disciplines that teachers design lesson and learning environments engaging students to process of science. The outcomes of STEM learning make students in new experiences, wide range of thinking, and let them do as scientists. In response to Thailand 4.0 model, innovation is called for any level of social movements. It also includes in educational system, critical thinking and other higher-ordered thinking play a vital role as an important skills to lead to the innovation (Jones & Pimdee, 2017). In this study, researchers employ action research to enhance critical thinking of grade 10 students through inquiry-based STEM learning. It helps teachers to design lesson for integrated learning as well as nature of learning in this era. Inquiry-based learning is suitable for science learning, invite student to meet the goals of science education, and also learn science through scientists-like as well.

METHOD

The action research was used in this research to develop the critical thinking of grade 10 students. The study conducted on first semester in academic year 2018. More details can be described in the following.

Students who participated in this research were initially screened through the preliminary testing. Critical thinking test was employed, grade 10 students were screened to target group by testing

their critical thinking from one classroom of one school from Mahasarakham province, Thailand. Twenty one students were participated in this study, they cannot passed criteria in 70% of critical thinking score.

The research instruments were created and used in the relation to purpose of study. Lesson plan, critical thinking test, observational form, and interviewing were constructed.

Lesson plan: Six lesson plans with 12 hours of inquiry-based STEM learning were constructed by employing 5Es as a main instructional strategy and then integrated STEM approach into learning activities. The spiral 1 implement 3 lesson plans, each lesson plans spent 2 hours. Three topics were used: work and force, mechanical energy, and energy conservation. The spiral 1 implement 3 lesson plans, each lesson plans spent 2 hours. Three topic were used: Power, simple mechanical, and mechanical efficiency. Each lesson plans were corrected and checked its appropriateness by 5 experts. Then lesson plans were improved before implement to target students.

Critical thinking test: Twenty items of critical thinking test with 4 multiple-choice which employed Dressel & Mayhew (1954). The instrument was examined using Index of item-objective congruence by 5 experts. The test divided into 5 categories: namely, ability to clarify the problem situation, gather information, accept the agreement, set up the hypothesis, and reasonably conclude. Data can be shown in the result by means of spider map as 1-5.

Interviewing form: It was open-ended interview, main interesting questions focused on critical thinking ability, opinions on teaching and learning activities, and teachers' role. Each question was corrected and checked its appropriateness by 5 experts. Then it was improved before implement to target students.

An action research was employed and data collection was conducted (Kemmis et.al., 2013) which consisted of 4 steps: plan, act, observe, and reflect, two spirals were conducted (Figure 1).*Plan*: researchers started to survey contexts and problem in teaching and learning through empirical data by observing learning atmosphere and its environments. Also, documents analysis which related to critical thinking classroom, inquiry-based learning, and STEM education were investigated. Research instruments were created and developed.

Act: Spiral 1 used 3 first lesson plans, and Spiral 2 used 3 later lesson plans with target students in the following.

Observe: researchers observe learning behaviors, and then remarked some phenomena in each lesson plans. Learning achievement test and critical thinking test were investigated. Also, interview some target students about opinions toward inquiry-based STEM learning.

Reflect: researchers concluded data from testing, interviewing, and observation. Data were checked to answer purpose of study. Information and findings from the past steps was reflected in each spiral to answer the purpose of the study.

Data were analyzed by descriptive statistics in terms of frequency, mean, and percentage. Qualitative data were also provided for verifying opinions and learning progress of target students.

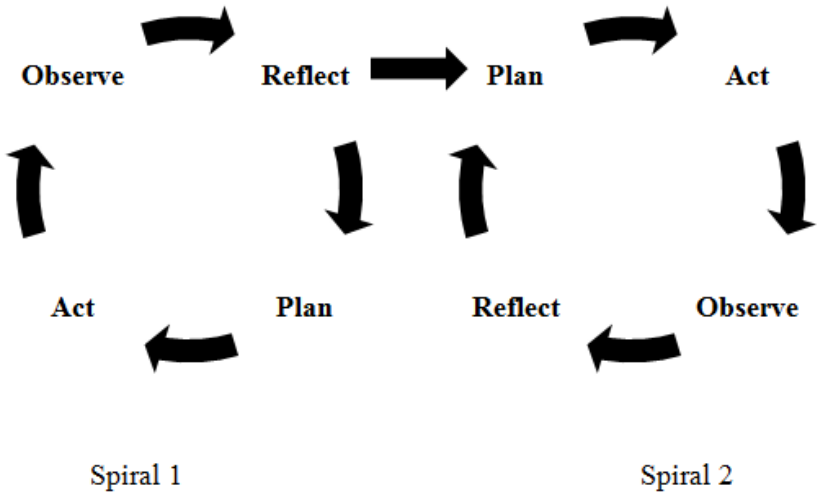


Figure 1. Two Spirals of Action Research

RESULTS AND DISCUSSION

To make sure in the process of selection in target students, critical thinking was tested. Students who are not passed the 70 percent of critical thinking score. Twenty one students are participated and experienced though inquiry-based STEM learning.

Spiral 1

Researchers have surveyed critical thinking of grade 10 students, and also interview physics teachers who have been taught. The qualitative data can be summarized in the following.

" ….most of the students have trouble with what is really the problem, stating that it therefore result in part of a critical thinking in order to solve such problems…."

(Teacher A, November 20th, 2018)

" … students often do not reflect information that is doing. Whether it be

from a source, which most often comes from the internet. They will make the decision to conclude an instantly from any such information....”

(Teacher B, November 20th, 2018)

“ … physics classes that students often have the problem, I need to bring that to solve the problem. Sometimes students do not have the skills to define assumption even. So if it comes to a critical thinking in physics, and then. Say no!...”

(Teacher C, November 20th, 2018)

Findings from empirical study, revealed that teachers need to help their students to gain more critical thinking and other learning outcomes. They would like to start their teaching and learning through situation or problem setting. Then, students have to think and do in their lesson by expressing necessary learning skills. The next steps of action research allow students by hands-on activity as well as scientific practices. Also, students are interviewed in the learning experiences. They express their feelings through qualitative information as below.

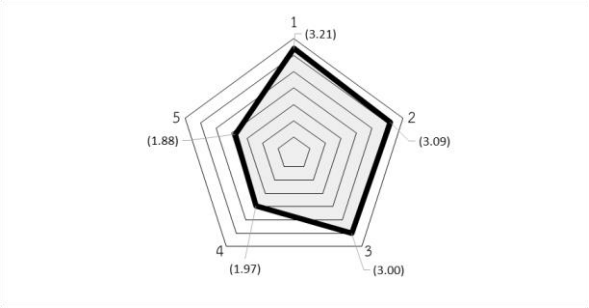
“ … have fun doing it, but rarely understand the lessons, practice it too difficult, then it never before done at all....”

(Students A, December 18th , 2018)

“ … only fun activities. Just finished answering questions, it may not be a lot like working group and other groups are not good....”

(Students B, December 18th , 2018)

From the interviews, researchers could conclude that the majority of the audience, students have trouble with doing because design-based activity is emphasized. That is, they are not familiar with learning activities. They need to study much more than those to expanding knowledge. After inquiry-based STEM learning implemented, found that students who had score lower than 70 percent is decreased (Figure 2).



(1) Ability to clarify the problem situation, (2) Gather information, (3) Accept the agreement, (4) Set up the hypothesis, and (5) Reasonably conclude

Figure 2. Critical thinking of grade 10 students in Spiral 1

Spiral 2

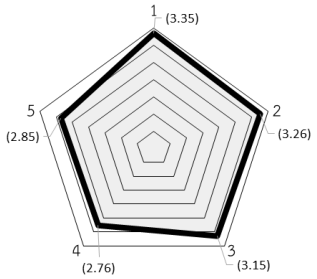
Researchers have surveyed critical thinking of grade 10 students, and also interview physics teachers who have been taught. The qualitative data can be summarized in the following.

“…fun activity, but the lesson didn't quite understand....”

(Students B, January 14th , 2019)

"…doing and design is a fun story. The part that I don't like is to practice by yourself. It's very difficult to understand because we have no an example...."
(Students C, January 14th , 2019)

The interview research can be concluded that the majority of students have trouble with lesson summary. Some students still have problems with the data research. To conclude, and to solve the problem found that some students prefer to perform activities in the lesson with activities to create artifacts only. After inquiry-based STEM learning implemented, found that students who had score lower than 70 percent is decreased more than Spiral 1 (Figure 3).



(1) ability to clarify the problem situation, (2) gather information, (3) accept the agreement, (4) set up the hypothesis, and (5) reasonably conclude

Figure 3. Critical thinking of grade 10 students in Spiral 2

Inquiry-based STEM learning helps students to gain more critical thinking, especially in the expanding knowledge period that students learn to connect prior knowledge and new experiences. They can design and create innovation to solve the problem, cooperative learning is employed during classroom activities (Hinton et.al., 2014). However, information technology and learning resources are very important to students (Parappilly et.al., 2013; Dostal et.al., 2018). The integrated learning in the physics classroom contexts must expand prior knowledge that the students will be creating a piece of work to solve the problem. Teacher has to add the rules by having students create hypotheses came up before (Bybee, 2010; Reeve, 2015). They can be redeemed for equipment to create their own piece of work. Thus, students pay their attention to practice with critically and innovatively.

CONCLUSION

Inquiry-based STEM learning can gain critical thinking of target students. In first spiral, the most probably reason might be the emphasis on defining the problem which allow students to practice with the variant situation. Student can solve problem based on planning, designing, testing, and sharing knowledge. However, the initial stage students are not familiar with learning situation. Teacher has to engage and reinforce them with various kinds of psychological methods. In second spiral, the issue from the last spiral was solved and explicated. The critical thinking of

students was continually improved, they focus on the lesson by making connection between prior knowledge and new experiences in systematically and critically designed.

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