Exploration of Students’ Metacognitive Experience in Physics Classroom

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Abstract. Metacognition has been accepted as one desirable attribute for learners in the 21st century. There are a number of research studies related to how to promote metacognition in school students. This study aimed to explore students’ metacognitive experience in one physics classroom in the equilibrium of moments topic. The research participants were 35 Grade 9 students from one secondary school located at Nakhon Ratchasima province in the northeastern region of Thailand. After learning physics, the participating students were asked to respond to the Metacognitive Experience Questionnaire (MEQ). The students’ metacognitive experience was analyzed for mean and standard deviation. The finding revealed that the students derived the neutral to frequently levels of experience in metacognition in the physics classroom. This finding suggests to add more metacognitive experience for Grade 9 students.

Keywords: Metacognitive experience, physics classroom, secondary school, Thailand

1. Introduction
Metacognition generally refers to thinking about thinking or knowing about knowing. It is commonly believed that metacognition can help individuals learn more effectively or reach higher learning achievement. Empirically, several studies affirm that when students develop their own metacognition; from developed metacognition, they subsequently develop other desirable characteristics as learning achievement, critical thinking skill, problem-solving skill, decision making skill, and awareness and environmental conservation behaviors [5,13].

There are several teaching strategies effectively develop students’ metacognition as the 5E and 7E learning cycle, open-ended problems, constructionist activities, and Tri-Sik-Kha principle-based teaching [14-20]. The questions generated during teaching influenced how students learned and studied, especially their metacognition [8].

Young children have more trouble than older ones in a comprehension process. Moreover, young children have less ability to develop metacognitive knowledge than older ones. They face the difficulty in feeling, planning, monitoring and evaluating their learning when they face difficult problems or situations to solve [7]. In other words, young children face the difficulty regarding metacognitive awareness; they
hardly realize that whether their learning is progressing well or failed. Metacognitive awareness takes part in metacognitive experience in a sense that metacognitive experience prefers awareness linking the present with the past learning experiences in order to facilitate learning in the present and in the future. Therefore, reflection upon learning experience of oneself can benefit individual’s metacognition [6]. Up to this, metacognitive experience and an ability to reflect upon it are regarded as the important component of effective learning for students in science classrooms.

The research question of this study is: What are the metacognitive experiences that the Grade 9 students derive during their learning in the physics classroom? Regarding this research question, the research objective is: To explore the characteristics of metacognitive experience that the Grade 9 students derive during their learning in the physics classroom.

2. Literature Review
This section illustrates the literature review about impact of metacognition, development of metacognition and metacognitive experience.

2.1. Impacts of metacognition
Ruangsri [18] studied about a relationship between metacognition and critical thinking of Grade 6 students. The researcher found that the multiple correlation coefficients between the subcategories of metacognition and the sum of all subcategories of critical thinking were significant at the .01 for all values and the multiple correlation coefficients between the subcategories of metacognition and each subcategory of critical thinking were statistically significant at the .01 level for all values. The beta weight values in each subcategory of metacognition positively contributed to the sum of all subcategories of critical thinking for all values. However, some subcategories of metacognition were negatively contributed to critical thinking.

The effect of a metacognition training with attribution training to effort on problem-solving skills of Grade 7 students was studied by Wongmak [26]. This research conducted with the three groups: the control group, the experimental group 1 received a training on metacognition and attribution to effort and the experimental group 2 receiving a metacognition training only. After training, the experimental groups 1 and 2 received higher problem-solving skill scores at the .05 level of significance; while the control group received lower problem-solving skill scores.

Prasertsook [17] studied Grade 8 students’ scientific problem solving ability, metacognition development and scholastic achievement in work and energy topic by using metacognitive strategies. Four metacognitive procedures were 1) analyzing problems, 2) planning to solve problems, 3) managing problems and 4) evaluating problems. Metacognition helped students develop scientific problem-solving ability as students analyzed and planned to solve scientific problems. The students applied metacognitive procedure to solve situation they received. The metacognitive learning affected students’ achievement.

Learning management by using metacognition strategy to develop the scientific problem solving skills for Grade 7 students was studied in Peungsaijai [14]. The efficiency of the metacognition learning plan to develop the scientific problem-solving skill was at 85.86/81.66. When the students used metacognition strategy, they had higher scientific problem-solving skill and learning achievement at the .05 statistically significant level. The students satisfied with the metacognition learning management at the highest level.

Nonjuy [12] studied the effect of metacognitive strategy on decision making and problem solving abilities in force and motion topic for Grade 9 students. The results showed that, after learning through metacognitive strategy, the student’s post-test average score of decision making and problem-solving abilities were significantly higher than pre-test at the .01 statistically significant level.

Decision making and problem solving abilities in science learning through metacognitive strategy was studied by Senruang [22]. The metacognitive strategy increased the students’ post-test mean score of
decision making and problem-solving abilities to be significantly higher than pre-test at the .05 statistically significant level.

Teprattananan [23] studied the effects of cooperative learning activities management integrated with metacognitive thinking on learning achievement and metacognitive thinking ability of Grade 10 students. The results revealed that the students who learned with cooperative learning integrated with metacognitive thinking has higher learning achievement and metacognitive thinking ability than those who learned with cooperative learning only at the .05 statistically significant level.

Development of knowledge and understanding, critical thinking, awareness, environmental conservation behaviors of Grade 12 students using the good science thinking moves with metacognition techniques was studied in Ladawan [9]. The lesson plans using the good science thinking moves with metacognitive techniques had an effectiveness index of .7290. The students in the experimental group developed higher knowledge and understanding, critical thinking, awareness and environmental conservation behaviors (p<.001). In overall, gender did not affect different learning outcomes.

Lertchuwongsa [10] used problem-based learning to promote metacognition and mathematics achievement of Grade 10 students. The problem-based learning increased the students’ metacognition mean score from a moderate level to a good level. Also, most of the students (more than 80%) had mathematics achievement mean scores higher than the minimum criteria at 60%. The mathematics achievement mean score, in overall, was 14.9 of 20 points (74.5%).

In summary, many studied confirm that when teachers developed metacognition in their students; the students also developed other desirable attributes as learning achievement, critical thinking skill, problem-solving skill, decision making skill, and awareness and environmental conservation behaviors.

2.2. Development of metacognition

Chansana, Suksringarm and Parakham [3] compared effects of the 7E learning cycle using metacognitive moves on Grade 5 students’ alternative conception in biology and basic science process skills. The results showed that the 7E learning cycle using metacognitive moves helped students gain more understanding about biology concepts at the .05 level of significance. The students developed basic sciences process skills higher than the 50% criterion at the .05 level of significance. In addition, the female students significantly evidenced more innering skills than the male students.

The effects on using open-ended problems to develop metacognition for Grade 9 students was studied by Pitchayanurat [16]. Using open-ended problems could help 80.95% of the students passed the metacognition test criterion of 50%. The students also showed a “good” level of metacognition practice with mean score of 2.96.

Thatsamee [24] developed the physics learning activities to develop problem solving ability with metacognition for Grade 10 students. The results showed that 80.95% of the students passed the physics problem solving ability test with criterion of 70%.

The effects of science learning management on Grade 10 students through learning cycle with metacognitive reflection and awareness were studied by Yutuuam [27]. There was no interaction between types of learning management and basic scientific knowledge. The students who learned with the learning cycle with metacognitive reflection and awareness (LCMRA) performed the highest learning outcome, scientific problem solving ability and metacognitive ability, followed by those learned with the learning cycle with metacognitive reflection (LCMR) and learning cycle (LC) only. The degree of student basic scientific knowledge corresponded with the degree of achieved learning outcome, scientific problem-solving ability and metacognitive ability.

Na Phatthalung [11] studied the results of 5E instructional model with metacognitive reflection strategies on science learning achievement, science concepts and metacognition of upper secondary school students. After learned with the 5E instructional model with metacognitive reflection strategies, the students in a bright, moderate and weak groups had higher science learning achievement, science
concepts and metacognition than priori at the .01 of significance. Also, the students had science learning achievement higher than the criteria of 60%.

The development of metacognition by using constructionist activities in the topic of evolution for Grade 12 was done in Sangwong [19]. The constructionist activities could develop Grade 12 students’ metacognition in a high level. This was occurred from the characteristic of constructionist activities as working with multiple formats, a teacher allowing students to discuss and share ideas both in and outside the classroom.

Phuaphan [15] studied effects of instruction based on Tri-Sik-Kha principle for developing Grade 10 students’ metacognition in the Ecosystems and Human and Sustainable Environment topic. The result showed that the instruction based on Tri-Sik-Kha principles could develop the students’ metacognition. The student average score of metacognition was very high at 70.35%.

In summary, many researchers tried to apply several teaching strategies, that is, the 5E and 7E learning cycle, open-ended problems, constructionist activities, and Tri-Sik-Kha principle, in order to develop students’ metacognition. Importantly, all teaching strategies can develop the participating students’ metacognition in a positive way.

2.3. Metacognitive Experience

Metacognitive experience is a part of metacognitive knowledge involved with knowledge about persons, goals, tasks and strategies. Metacognitive experience generally refers to one’s experience regarding feelings, estimation or judgments in his/ her learning process during completing the specific task. Metacognitive experience refers to one’s awareness linking the present with the past learning experiences that can facilitate learning in the present as well as in the future.

Cognitive and affective factors are two factors that can affect one’s metacognitive experience by triggering or impeding his/ her cognition and behavior related to effective learning in both short- and long-terms [5].

Metacognitive experience takes role in self-regulation that can provide an input to activate one’s metacognitive skills to control learning action and behavior [4]. For example, learners’ feeling of difficulty can be attributed to task complexity, task demands, or a lack of competence to deal with the task. The outcome of cognitive process and detects the discrepancy from the goal set can also affect one’s metacognitive experience. We call these as feedback loops [2].

3. Methods

3.1 Research participants

The research participants were 35 Grade 9 students from one classroom in one secondary school located at Nakhon Ratchasima province in the northeastern region of Thailand. The age of students ranged between 15-16 years. The students were in the final year of their lower-secondary school level. They all volunteered to participate in this study.

3.2 Data collection

After learned in one topic of the physics class, the students were asked to respond to the Metacognitive Experience Questionnaire (MEQ), which was consisted of 17 items. The MEQ is divided into three parts. The first part was consisted of nine items (items 1-9) asking for Monitoring, Evaluation and Planning (MEP). The second part was consisted of five items (items 10-14) asking for Learning Risks Awareness (LRA). The third part was consisted of three items (items 15-17) asking for Control of Concentration (CC).
3.3 Data analysis

The students’ responses of MEQ were quantitatively analyze for means and standard deviation (S.D.) by using the SPSS statistical package. The mean scores were interpreted according to these criteria. The mean scores between below 1.00-1.50, 1.51-2.50, 2.51-3.50, 3.51-4.50 and over 4.51 was interpreted as never, rarely, neutral, frequently and always, respectively.

4. Results

Mean scores and associated S.D. of each item in the MEQ were calculated and interpreted as table 1.

| Metacognitive Experience | mean  | S.D.  | Interpretation |
|--------------------------|-------|-------|----------------|
| 1. I adjust my plan for a learning task if I am not making the progress I think I should. | 2.77  | 1.00  | Neutral        |
| 2. I plan to check my progress during a learning task. | 2.74  | .74   | Neutral        |
| 3. I try to understand clearly the aim of a task before I begin it. | 3.94  | .90   | Frequently     |
| 4. I evaluate my learning processes with the aim of improving them. | 3.37  | .80   | Neutral        |
| 5. I consider what type of thinking is best to use before I begin a learning task. | 3.40  | .84   | Neutral        |
| 6. I consider whether or not a plan is necessary for a learning task before I begin that task. | 2.83  | .89   | Neutral        |
| 7. I stop from time to time to check my progress on a learning task. | 2.77  | .97   | Neutral        |
| 8. I try to predict possible problems that might occur with my learning. | 3.17  | 1.01  | Neutral        |
| 9. I assess how much I am learning during a learning task. | 3.49  | .88   | Neutral        |
| 10. I am aware of when I am about to have a learning challenge. | 3.40  | .84   | Neutral        |
| 11. I am aware of when I am about to loose track of a learning task. | 3.54  | .86   | Frequently     |
| 12. I am aware of when I don’t understand an idea. | 3.54  | 1.03  | Frequently     |
| 13. I am aware of when I have learning difficulties. | 4.09  | .70   | Frequently     |
| 14. I am aware of when I am not concentrating. | 3.54  | 1.09  | Frequently     |
| 15. I adjust my level of concentration, depending on the learning | 3.46  | 1.01  | Neutral        |
I adjust my level of concentration depending on the difficulty of the task.

I adjust my level of concentration to suit different science subjects.

Overall

Table 1 indicated that, in overall, the participating students frequently derive metacognitive experience in the physics classroom (mean = 3.41, S.D. = .88). Of 17 items, there were seven items rated in a frequently level and 10 items rated in a neutral level of experience related to metacognition.

Considering Grade 9 students’ metacognitive experience in MEP, the participating students showed the neutral level of experience concerning MEP (see Table 2). They had a frequently level of MEP experience regarding item 03 “I try to understand clearly the aim of a task before I begin it.”

Table 2. Grade 9 students’ metacognitive experience in MEP (n = 35)

| MEP component                                                                 | mean | S.D. | Interpretation |
|------------------------------------------------------------------------------|------|------|----------------|
| 1. I adjust my plan for a learning task if I am not making the progress I think I should. | 2.77 | 1.00 | Neutral        |
| 2. I plan to check my progress during a learning task.                       | 2.74 | .74  | Neutral        |
| 3. I try to understand clearly the aim of a task before I begin it.          | 3.94 | .90  | Frequently     |
| 4. I evaluate my learning processes with the aim of improving them.          | 3.37 | .80  | Neutral        |
| 5. I consider what type of thinking is best to use before I begin a learning task. | 3.40 | .84  | Neutral        |
| 6. I consider whether or not a plan is necessary for a learning task before I begin that task. | 2.83 | .89  | Neutral        |
| 7. I stop from time to time to check my progress on a learning task.          | 2.77 | .97  | Neutral        |
| 8. I try to predict possible problems that might occur with my learning.     | 3.17 | 1.01 | Neutral        |
| 9. I assess how much I am learning during a learning task.                   | 3.49 | .88  | Neutral        |
| Overall                                                                      | 3.16 | .89  | Neutral        |

Regarding Grade 9 students’ metacognitive experience in LRA, the participating students showed the frequently level of experience concerning LRA. They had a neutral level of LRA experience regarding item 10 “I am aware of when I am about to have a learning challenge” as Table 3.
Table 3. Grade 9 students’ metacognitive experience in LRA (n = 35)

| LRA component                                                                 | mean | S.D. | Interpretation |
|------------------------------------------------------------------------------|------|------|----------------|
| 10. I am aware of when I am about to have a learning challenge.               | 3.40 | .84  | Neutral        |
| 11. I am aware of when I am about to lose track of a learning task.           | 3.54 | .86  | Frequently     |
| 12. I am aware of when I don’t understand an idea.                            | 3.54 | 1.03 | Frequently     |
| 13. I am aware of when I have learning difficulties.                          | 4.09 | .70  | Frequently     |
| 14. I am aware of when I am not concentrating.                               | 3.54 | 1.09 | Frequently     |

Overall                                                                  3.64  .90  Frequently

Table 4 showed that Grade 9 students derived the frequently level of experience concerning CC. They had a neutral level of LRA experience regarding item 10 “I adjust my level of concentration, depending on the learning.”

Table 4. Grade 9 students’ metacognitive experience in CC (n = 35)

| CC component                                                                 | mean | S.D. | Interpretation |
|------------------------------------------------------------------------------|------|------|----------------|
| 15. I adjust my level of concentration, depending on the learning.           | 3.46 | 1.01 | Neutral        |
| 16. I adjust my level of concentration depending on the difficulty of the task. | 4.34 | .59  | Frequently     |
| 17. I adjust my level of concentration to suit different science subjects.   | 3.69 | .93  | Frequently     |

Overall                                                                  3.83  .84  Frequently

5. Discussion
In a holistic view, Grade 9 students derive only a neutral level of experience related to metacognition in their physics classroom. Up to this, we as science or physics educators, need to provide more metacognitive-related experience to our students in physics classrooms in order to help students derive higher level of metacognitive experience, for example, from the neutral to the frequently levels.

Comparing between MEP, LRA and CC, Grade 9 students derive MEP-related experience less than LRA- and CC-related experience. So that, the physics teachers should provide more opportunities for students to plan, evaluate and monitor their own learning. This cannot be accomplished with the lecture-based teaching style as being normally found in physics classrooms in Thailand. Physics teachers should change their teaching paradigm to constructivist teaching paradigm. The physics students should have more chance to act as active learners and, in the same sense, the physics teachers should act as facilitators.
Several constructivist teaching strategies should be employed in physics classrooms such as inquiry, learning cycle, problem-based learning, project-based learning, STEM (Science-Technology-Engineering-Mathematics) and so on.

In addition, to derive more complete picture of metacognitive experience in physics classroom, we need more measurement tools. The findings from this study may face its limitation regarding the use of single instrument and method to collect data about metacognitive experience. Schraw [20] refers to the difficulty of measuring metacognition and states that using a single method is not enough to explore all dimensions of such a complex process as metacognitive process. Regarding this, Akturk and Sahin [1] state that the researchers in metacognition field need the tool to measure metacognition and its related components. The metacognition researchers should utilize more than one tool to measure metacognition in their research sample or participants.

6. Implication
This study urges for the need to develop MEP-related experience for students in physics classrooms. However, the LRA- and CC-related experience should be developed in physics students as well. In addition, the research about metacognition should apply diverse tools, methods and methodologies in studying about metacognition. Regarding this, the qualitative or mixed-method tools should be considered to apply in metacognition-related research in order to capture the complexity of metacognitive process.

Scoot [21] mentions the power of interview in uncovering students’ metacognitive process. Interview questions demand students as the interviewees to expand or clarify their answers. In the opposite way, the use of questionnaire in studying about metacognition should not be neglected. The utilization of questionnaire is useful in a sense that it can be applied with a large sample size. It is easier and quicker for the researchers to interpret the data derived from the questionnaire. The questionnaire can be use for quick survey and evaluation of metacognition in respondents [25].

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