Examining Grade 5 students’ capability of analytical thinking in learning about heat conduction through Predict – Observe – Explain (POE) strategy

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Abstract. The paper aimed to examine Grade 5 students’ capability of analytical thinking in learning about heat conduction of the Materials Unit through Predict – Observe – Explain (POE) strategy. Participants included 40 Grade 5 students in Khon Kaen University Demonstration Primary School (Modindaeng). Methodology regarded classroom action research. The POE heat conduction teaching was provided in the Material unit for 6 periods. Tools for interpretation included participant observation, students’ tasks, and informal interview. The findings revealed that students’ reasons provided some aspects of analytical thinking but the majority of students could not show all three aspects of analytical thinking – analytics for important issues, relation, and rational. The majority of students could mention about analytical thinking in dimension of rational but they could not clarify theories related to rational.

Keywords: primary school students, heat conduction, POE, analytical thinking

1. Introduction

Nowadays, science and technology play an important role in daily life of humans and also national development. The developed countries attach importance to the teaching of science and technology. Thailand also attaches importance to the teaching and learning of science and technology as well. The National Education Act 1999 (revised 2002) has focused on the development of Thai people to be perfect humans, both physically, mentally, intellectually, knowledge and morality. Educational management must be under the concept that all learners are able to learn and develop themselves and are considered the most important. To achieve this objective, teachers must focus on teaching students to create scientific concepts and understand the nature of science. Therefore, in the learning management of students must occur from real situations and emphasize the process for students to develop critical thinking, expressing opinions, and seeking self-knowledge. For students to be able to adjust and solve life problems under their social and environmental contexts, the teaching and learning must focus on the students-centered [1], [2].

Science plays a very important role in today’s global society and the future, because science involves everyone, both in daily life and in various careers. Technology, equipment, and various products that humans have used to facilitate life and work are created from science combined with creativity and other knowledge. Science helps humans to develop methods of thinking. As well as important skills for finding knowledge, have the ability to solve problems in a systematic way, able to
make decisions by using a variety of information and testimony. Science is a culture of the modern world, the Knowledge-based society. Therefore, everyone needs to be developed to know Science. In order to have a better understanding of nature and technology, student could able to apply knowledge with reason, creativity and virtue. [3], [4], [5].

Learning science should be focused on preparing students to live life in today's science and technology society. Learning science should not only encourage students to understand scientific concepts, but also should let students have a logical analysis of how did the conclusion come to be credible? Being aware of the aforementioned science teaching will encourage students to learn science for science [6]. Therefore, analytical thinking cannot be separated from science learning. Analytical thinking based on Bloom's Taxonomy (1956) considers analytical thinking an ability to distinguish to find a subset of events, stories or content that compose of how important, what is the result and what is the reason? The analysis is divided into 3 ways as follows [7].

1. Analysis of Significance means to distinguish the things that are important or necessary. What's the most important role? What is the reason? What is the result?

2. Analysis of Relationship means finding out how the important of sub-stories or sub-events are related. How are they consistent or conflicting?

3. Analysis of Organizational Principles refers to finding the structure and system of the various stories and actions about what can make them unite.

Another strategy for science learning that gives students the opportunity to create meaning for science concepts by themselves and to promote critical thinking is Predict - Observe - Explain (POE). POE is a method that encourages students to make decisions about existing understanding and is based on the prior knowledge. White and Gunstone [8] stated that POE is an effective way to encourage students to express their ideas and discuss scientific concepts. POE is a process of presenting a situation and asking students to predict what will happen if it changes. After students have predicted, students observe the situation with which students have experimented to find the answer from the situation that the teacher has prepared. After that, students present to the class what they observed from their inquiry. And finally, students have to explain the differences between what is predicted and the observation or the results. The organizing teaching and learning activities by the POE method is to emphasize the importance of the nature of science that students practice working as scientists. In which students must use scientific methods to search for knowledge both observation, determine hypothesis, experimental design, and do the experiment, which is a step in the scientific inquiry. When getting the results, students must explain the results of the experiment. So, POE is a method that encourages students to create knowledge by themselves based on their basic knowledge from their experiences in scientific inquiry that is in accordance with the aims of science teaching in Thailand and in accordance with the concept of constructivist theory [9].

The researchers were interested in studying the students’ capability of analytical thinking using science learning management Predict - Observe - Explain (POE) strategy. Analytical thinking is a skill that promotes students’ learning which they need to practice and develop into habits for encourage the learners to have broad and deep thinking ability. Training students to think critically will enable students to identify the cause for the outcome lead to comparative analysis capabilities, to decide the most appropriate and worthwhile cases which will lead to the development of the person's ability to analyze and solve problems or making decisions in their daily life. This paper analyzes the analytical thinking of students from learning about heat conduction using POE strategy in various materials unit.

2. Methodology
Methodology regarded classroom action research. The objective of research was to study grade 5 students’ capability of analytical thinking in learning activities about heat conduction in various materials unit using the Predict - Observe - Explain (POE) strategy. The classroom action research was organized for 4 cycles (24 lesson plans) of primary school science unit of various materials, force and pressure in order to understand what teacher’ learning about improving students’ capability of analytical thinking. In this paper, the third cycle of classroom action research will be highlighted what we learned about students’ capability of analytical thinking. The third cycle called “learning unit about various materials” that consisting of 6 lessons. The POE heat conduction teaching was provided in the
Material unit for 6 periods. Tools for interpretation included participant observation, students’ tasks, and informal interview. Students’ capability of analytical thinking will be interpreted through coding in the table 1.

2.1 Participants
Participants included the students in grade 5/2 who were studying in the academic year 2011, Khon Kaen University Demonstration School (Mor Din Daeng), 1 classroom of 40 students.

2.2 Data collection
In classroom action research, the first author conducted the teaching by herself. The heat conduction learning unit was provided called “learning unit about various materials” that consisting of 6 lessons. The method of data collection could be highlighted regarding on the steps of classroom action research as following.

2.2.1 Preparation stage before conducting data collection, the researcher prepared as follows
1) The research assistants are teachers who teach science subjects. The research assistants are the data collectors. The research assistants are teachers who teach science subjects. The research assistants are the data collectors. The authors guide data collection, observation, recording, and the collecting data tools.

2) The researcher prepared materials, teaching and learning equipment media, learning materials for classroom management, work sheets, knowledge sheets, equipment for doing activities. Also, the equipment for data collection such as the observation form, the interview form, the analytical thinking evaluation form, a video recorder Voice recorder were prepared.

3) The researcher prepared a place for teaching and learning. Moreover, prepared laboratory for each experiment too.

4) Student orientation before the experiment, the researcher clarify the learning objectives and communicate about analytical thinking, organizing learning activities using Predict -Observe-Explain (POE) for students to understand the rules in the classroom.

2.2.2 Action stage
1) The researcher conducted 24 lesson plans using Predict -Observe - Explain (POE) for 2 months total time is 24 periods.

2) Researchers and research assistants recorded data during teaching by interviewing students and recorded their answers.

3) The researcher conducted data collection and categorize data after that interpret the data gained from observation and interviews. The researcher analyzed the behaviors of the students in various aspects in the worksheet, workload, work piece, and then grouped the data. Analyze, interpret, to focus on the students’ critical thinking abilities. From learning management using Predict -Observe-Explain (POE) strategy then summary, writing report.

2.2.3 Reflection stage
The reflection about what the teacher and observers’ learning about students’ improving on capability of analytical thinking in the POE material unit was organized for each cycle of classroom action research. The teacher and observers’ reflection were audio recorded. These reflections would be viewed as peer debriefing of what teacher and observers’ understanding on students’ capability of analytical thinking.

2.3 Data analysis
The process of data analysis is as follows
1) Interpret the analytical behavior of students from information obtained from video shooting, interview, audio recording, worksheet, observation of students’ behavior that occurs during instruction. In each lesson plan, data was interpreted according to the behavioral framework that expresses the characteristics of analytical thinking in Table 1 and researchers wrote the discussion in groups and individually.

2) Bring the analysis data together to analyze the interpretation again with the advisor for credibility. The data was presented by description interpret the analysis of student behavior. The data

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from the Analytical Thinking Behavior Form was analyzed the answers from the questions on the worksheet. Then evaluated in the form of a written essay. Detailed descriptions of data collection, analysis of discovered data, and judgment of those data for analysis on various issues.

Table 1: Coding of students’ capability of analytical thinking

| Capability of analytical thinking | Coding | Example of behaviors                        |
|---------------------------------|--------|-------------------------------------------|
| Analytical thinking for key importance | I1     | Analyze key components of stories or problems |
|                                   | I2     | Interpret the meaning of stories or problems |
|                                   | I3     | Identify the rational of stories or problems |
|                                   | I4     | Order the components of stories or problems |
| Analytical thinking for relationship | R1    | Identify the relationship of key important components. |
|                                   | R2     | Identify rational of relationship of component |
|                                   | R3     | Compare and contrast each component for discussion |
|                                   | R4     | Identify connecting and relating / misrelating among components |
|                                   | R5     | Identify problem related to everyday life |
| Analytical thinking for principles | T1     | Collect data and identify for key components based on principle |
|                                   | T2     | Interpret or construct meaning or knowledge related to stories or problems |
|                                   | T3     | Conclude and make decision based on knowledge or appropriate ways of solving problems |

3. Findings

The instruction of materials unit through Predict – Observe – Explain (POE) strategy was provided to enhance Grade 5 students’ capability of analytical thinking in learning about heat conduction. There were two POE learning activities including 1) mixing up hot Ovaltine, and 2) molding clay on conducting pot.

3.1 Students’ capability of analytical thinking in learning of mixing up hot Ovaltine

The activity of mixing up hot Ovaltine asked to predict about temperature on the different material Ovaltine cups. The material cups included glass, tile, stainless, paper, wool, and plastic. Students need to predict which one is the hottest cup. Then, students clarify their reason on the stage of prediction and explanation. Students’ capability of analytical thinking in learning of mixing up hot Ovaltine could be interpreted as the table 2.

Table 2: Students’ capability of analytical thinking in learning of mixing up hot Ovaltine

| Capability of analytical thinking | Prediction on Ovaltine cup | Explanation on Ovaltine Cup |
|---------------------------------|---------------------------|----------------------------|
|                                 | Frequency | Percent | Frequency | Percent |
| Analytical thinking for key importance | 16 | 32.00 | 19 | 32.20 |
| Analytical thinking for relationship | 11 | 22.00 | 9 | 15.26 |
| Analytical thinking for principles | 23 | 46.00 | 31 | 52.54 |
| Total                           | 50 | 100.00 | 59 | 100.00 |

The student concepts which are interpreted to show analytical thinking ability in Table 2 are mainly analysis of principles. However, many students do not explain the meaning of the principles or the relationship of cause and effect. Therefore, most of the concepts of students can be interpreted as analytical thinking in some capabilities of analytical thinking instead of all 3 capabilities. Examples of
student explanations that can be interpreted as analytical thinking in 3 capabilities: analysis of importance relationship analysis and principle analysis are the answers of Peeramon and Ketmanee.

Peeramon explained the reasoning in the prediction step of Ovaltine brewing activities by trying to use the concept of heat retention as the principle. Why plastic cups cause Ovaltine to cool faster and can be eaten more easily. Although, the principles she explained do not specify that regarding the thermal conductivity. The explanation of the material is unable to accumulate heat. This can explain the thermal conductivity and with this analytical principle, Peeramon shows the importance of analysis. Because she can use her principles to tell the cause of the story and can be interpreted as having relationship analysis because using this principle weld the ability to conduct the heat of the loaded container with the heat of Ovaltine and ease of drinking.

In the explanatory stages of Ovaltine brewing activities. There are examples of answers that can be interpreted as expressing Analytical thinking in three areas is the answer to Ketmanee. She acknowledges the problem of the thermal conductivity of the container and the ease of drinking (Significance analysis) and can use the term different heat conduction of materials as a principle. (Principle analysis) to tell the reason which glass is easier to drink (Relationship analysis). The concepts of Parimon and Ketmanee as follows

The glass that is easy to drink is plastic because plastic glasses can't keep the heat for a long time. Making it easy to drink "(Parimon, grade 5)

Delicious Ovaltine - Aluminum is the best in conduct heat. Plastic does not conduct heat at all because of glass, aluminum conduct heat makes us most difficult to drink. Plastics cannot conduct heat, which makes us easy to drink." (Ketmanee, grade 5)

However, most students' opinions are incomplete in all 3 areas. Some students specify only the principles. But do not understand the problem to explain the cause and effect of the matter. For example, Apicha gives a reason for the prediction. By simply specifying that the material is not a heat conductive material Show that he may have analyzed the principles But not aware of the importance of the problem that needs to explain the phenomenon. Other while, because they do not fully understand the science of heat conduction and some students only show the importance of analysis, such as Ketmanee, who predicts that Plastic cannot keep heat shows that Ketmanee understood the importance of the story as the cause of heat but didn't explain the relationship. In the explanatory stage, there are many students who express their analytical thinking by only analyzing principles such as

"The glass that is easy to eat is plastic because plastic is not a material that contributes to heat." (Apicha, grade 5)

"The glass that is easy to eat is plastic because it cannot store heat." (Ketmanee, grade 5).

"Delicious Ovaltine - glasses made from stainless steel because it conducts heat well." (Kantawee, grade 5)

Students may use principles to explain by observing the occurrence of social phenomena, which their reasons also reflect the analytical significance and relationship, such as Kittipot used the experience by observe from friends who drink milk to answer.

"The hottest cup is a cup made of glass because all friends cannot finish milk because it is hot." (Kittipot, grade 5)
3.2 Students’ capability of analytical thinking in learning of molding clay on conducting pot

Teachers proposed the situation of placing the molding clay on the different materials of pot. These materials included glass, copper, wood, aluminum, and iron. Then, teachers asked students that which pot will the best heating the molding clay. Then, students drew the pictures to represent their prediction. Below are examples of students’ drawing of prediction.

Figure 1: Peeramon’s drawing

Figure 2: Hathai’s drawing

Figure 3: Pun’s drawing
In the observation and explanation stages, most students simply stated that the conduction of heat but not trying to explain to connect with the situation of thawing clay, how fast is it? What’s the difference between it? What’s the effect on melting? If students are able to explain the importance of the situation by using scientific principles to link the relationship of the situation to the observed results. This can be assumed that students have created the definition of that science concept by themselves. But from the opinions that students explain, they often state the name of science only Instead of trying to communicate from the phenomena observed in the experiment

After prediction, students do experiments about heating pot. Then, they have to provide their explanation of experimentation. These could be interpreted as their capability of analytical thinking. Students’ capability of analytical thinking in learning of molding clay on conducting pot could be interpreted as the table 3.

| Capability of analytical thinking                      | Prediction on Conducting | Explanation on Conducting |
|--------------------------------------------------------|--------------------------|---------------------------|
|                                                        | Frequency | Percent | Frequency | Percent |
| Analytical thinking for key importance                 | 35        | 50.73   | 37        | 55.22   |
| Analytical thinking for relationship                   | 22        | 31.88   | 20        | 29.85   |
| Analytical thinking for principles                     | 12        | 17.39   | 10        | 14.93   |
| Total                                                  | 69        | 100.00  | 67        | 100.00  |

4. Conclusions and Discussion

Most students cannot show analytical ability in all three areas. They try to identify the principles, but they seem to be unable to analyze the importance and relationships of that situation. It may be because students may not have a complete understanding of heat conduction or may not be aware of the nature of science. For example, in scientific communication, scientists must communicate to the scientific community with empirical evidence and creating logical explanations instead of just scientific terms. The result shows that the ability to think critically is not complete in all three areas. May result from lack of conscience, science and unaware of the nature of science Therefore, science should be taught and emphasized in accordance with the nature of science [10], [11]. In addition, it is to affecting the creation of the meaning of science concepts and also helps to promote the analytical thinking of science learners [12].

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