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Developing Scientific Writing of Lower Secondary Students through Inquiry and Science Writing Heuristic Learning

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Abstract

This action research aims to develop scientific writing of lower secondary students through inquiry and science writing heuristic learning. Participants were 15 of grade 9 students from one school in Sisaket province, Thailand. Ten lesson plans including 15 hours, a scientific writing assessment form, and scientific writing interviewing form were employed for research instruments. Findings revealed that each spiral was 66.67%, 73.33%, and 100% of students who pass in scientific writing as following. That is could be discussed and promoted in the science classroom. Students need to be more improved their writing skills relevant to science.

Keywords: Inquiry, Science Communication, Writing Heuristic, Scientific Writing

INTRODUCTION

The knowledge and understanding of science and technology is important in preparing people to face the world of uncertainty, and also enable them to live with others. In essence, science and technology is useful knowledge for all and for basis of living and working in the daily lives. As science education do, teachers and students have to collaboratively learned science as nature of learning. Indeed, the world is now transforming to promote students to have scientific literacy and it necessary learning skills (El Islami & Nuangchalerm, 2020). These skills can enable students to be citizens in science, they might want to have 4Cs and 3Rs which 4Cs consisted of critical thinking, creativity, communication, and collaboration; 3Rs consisted of reading writing, and arithmetic. That is important tools of learning to all students in the world of uncertainty (Nuangchalerm, 2017).

Students can gain their scientific literacy and necessary learning skills in such learning through literacy program and embedded science communication. These skills are important to all students, it is not only science classroom, but also any subjects should be integrated. If students have not science communication skills, they have insufficiently ability to communicate with universal community. They have to reach the requirements of science literacy and improving science communication skills (Chen 2019). Students should have way of appropriate learning and can communicate with others. School science also provides them in knowledge, science process skills, and habit of mind which supports the nature of science. Successful learning in science is not only knowledge perceived by only classroom activities, but also other necessary learning skills should be prepared in other disciplines. Students must communicate of what they understand and feel towards science by effective communication (Lester & Foxwell-Norton, 2020).

Additionally, teachers should have a deeper understanding of curriculum, instruction, and assessment in which students participate in science classrooms. There are various methods that could be used to promote science literacy and communication skills. The inquiry method has been widely used in science because it can enhance learning competency, but it may produce different outcomes based on classroom contexts (Voet & De Wever, 2019). It leads students to have knowledge by hierarchical process of knowledge construction. Some research reported that inquiry can promote thinking classroom by instructional method and teaching strategies that teacher

considered Mubarok et.al., 2019; Onsee & Nuangchalerm, 2019). That is, such inquiry learning is entirely invited to science classroom. Students are having not only mind-on activity and hands-on activities but also argumentation about the meaning of inquiry-based science investigation as important classroom practices.

If students have not enough in such know and understand science, they cannot make reasonable to think, less opportunity to communicate science with others. They cannot expand their thinking and feeling to society, students must be offered opportunities to provide evidence for supporting claims, to attempt to persuade their peers, to ask the related question (Crawford, 2000). In doing scientific inquiry, students should have actively implemented in appropriate reasoning strategies by engaging in developing testable questions, proposing claims, and providing evidence regarding the inquiry investigation. The gap between the goals of the national science education standards and the practices of science teaching should be done (Nam et.al., 2011). Teacher can promote in students' creating the scientific explanation in which reliable communication as science do. Writing is skill to show evidence that present how students think, feeling, communicating, and sharing science in what they have (Nam et.al., 2008; Nam et.al., 2011; Jang et.al., 2012). That why school and educators promote science communication because information is now overloaded and less reliable. Students should be learned and made to face with science communication and make it to be more scientifically.

The science writing heuristic approach (SWH) is the one method that could use to achieve the goals that consist of writing skills, inquiry skills, and teamwork skills concurrently (Hand et.al., 2004; Burke et.al., 2005; Anisa et.al., 2019; Daningsih et.al., 2019). It works with a question, claims, and evidence structure promotes students' use of the argument structure as the core of any scientific inquiry activity (Keys et.al., 1999; Stephenson et.al., 2016). Then, students can create the meaning by scientific process and language about questioning, warrants, claims, evidence, and reflection. The SWH is an argument-based inquiry approach was developed to facilitate science learning from laboratory activities through the use of written and oral argumentation.

It helps students construct understanding during practical work. Students can to produce written explanations of the processes involved in the activity through completion of a template, with emphasis placed on claims, evidence and reflection (Burke

et.al., 2005). The heuristic is an instructional design model consisting of 2 parts: one for the teacher's actions and the other one is for student activities (Keys et.al., 1999; Hand & Prain, 2002; Hand et.al., 2004). Thus, this action research aims to develop science writing of lower secondary students through inquiry and science writing heuristic learning. It could help students to express what they think and feeling to science. That is necessary skills to communicate science with society and it should promote school science as well as process of science.

METHOD

The action research was used in this research for developing science writing of grade 9 students. The study conducted on second semester in academic year 2019. More details can be described in the following.

Participants

The participants consisted of 15 students attending grade 9 from one school in Sisaket province, Thailand. They are good students, but having science writing score less than 70% of school determined. They are purposive selection to be target group in the study.

Research instruments

The research instruments in this study consist of 4 instruments: lesson plans, the lesson plan employed inquiry-based (5E) with a science writing heuristic; science writing assessment form; and science writing interview form. The action instrument consisted of 10 lesson plans based on inquiry with science writing heuristic approach. Eight processes of SWH and 5 processes of the inquiry spiral were combined and implemented in science classroom.

Procedure

The study employed action research (Kemmis et.al., 2013) that is divided into 3 spirals. This study was an action research design that is divided into 3 spirals. Each spiral is provided in terms of plan, act, observe, and reflect in the following.

Data collection and analysis

Data collection was conducted (Kemmis et.al., 2013) which consisted of 4 steps: plan, act, observe, and reflect, two spirals were conducted (Figure 1). The action cycle is conducted with 3 spirals for improving scientific writing skills through inquiry and science writing heuristic learning.

Plan: researchers started to study classroom climate and contexts, and problem found in the leaning activities which related to science learning as its empirical data. In addition, documents analysis is employed for analyzing science writing. Then, research instruments were created and developed as experts provided its validity.

Act: Each spiral used 4 first lesson plans by inquiry with science writing heuristic.

Observe: researchers observed learning behaviors, and there remarkable some learning behaviors in each lesson.

Plan. Especially writing their worksheet and other writing products. Science writing test and other instruments were used for observing. Interviewing also employed for data collection in terms of qualitative data.

Reflect: researchers concluded data from a variety of research instruments. Data were checked to answer purpose of study. Information and findings from the past steps was reflected in each spiral to answer the aim of study. Data were analyzed by descriptive statistics in terms of frequency, mean, and percentage. Qualitative data were used for discussion in students' writing.

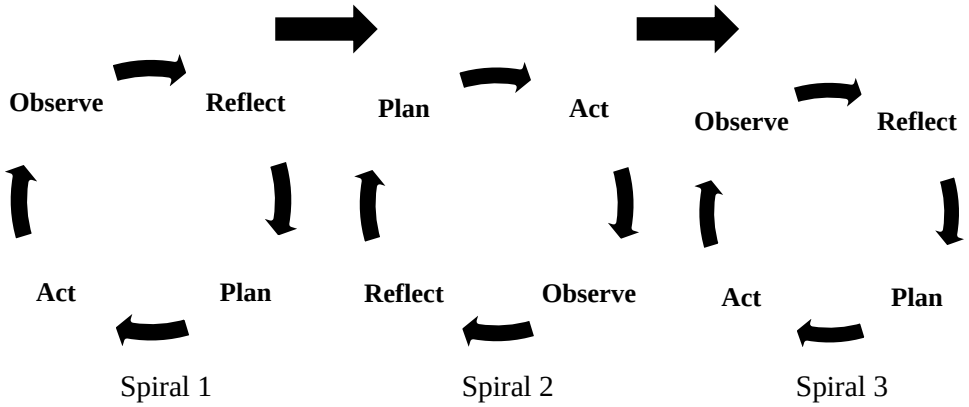

Figure 1. Three spirals of action research

RESULTS AND DISCUSSION

The result indicates that there is 66.67% of students pass the level of writing ability in the first spiral, 75.00%, and 73.33% in the 2nd and 3rd spiral in respectively (Figure 2).

Figure. 2 indicates that students have science writing level between spiral 1 and spiral 3, it found the second spiral has the highest level of science writing by at 75%. While the first spiral has the level of science writing is at lowest. Finding also showed the qualitative data in which obtained from data collected each process as detailed.

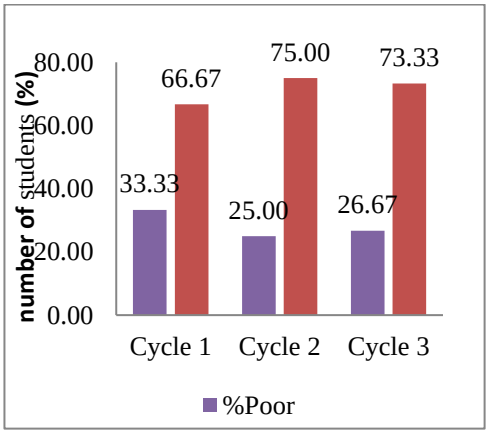

Figure. 2 Science writing level of each spiral

Engagement stage

In the beginning, this process will start with a Quiz to Knowledge check before learning by multiple instruments such as Quizwhizzer, Google classroom. Then, the media will be used to engage student and guide about the content by answering the questions in the beginning idea stage (Figure 3).

Exploration stage

This stage, students were guided about the subject in the previous stage, the students could know and understand which they have learned. Then, the students showed their questioning which relevant to the topics based on their interest via the questions by the teacher as follows:

"As mentioned previously (in the Engagement stage), What do students want to know?" – an exploration of pre-instruction understanding.

"What students have prior knowledge about the questioning?" - To check prior knowledge.

"What did you do?" - to discuss before the experiment and helps students to write the processes to answer their questions.

The question is that teacher asked in the beginning idea stage. In addition, to answering the question, students must also write in the worksheet. The first spiral, found the main problems that the students cannot make questions and some content which appear in the lesson, and also the question was not related to their claims. It affects to evidence that students provided to encourage their claim. Because of the learning process in the engagement stage was not clear. Teacher cannot tell students about contents in advance. Therefore, the students do not know about the lesson framework. Then, it makes students confused about what they want to know. As a result, the students unable to make their questions related to the lesson and compliance with their claims.

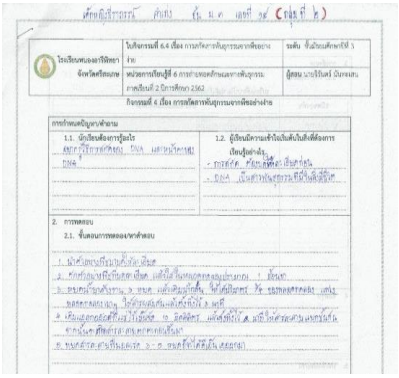

Figure. 3 Sample SWH template

According to an issue in the previous, the researcher improved the learning procedure in the next spiral also the teaching activities to be more experimentation. At the beginning idea stage, by adding questions to more clearly define the scope of the lesson as follows:

"From the foregoing, what do students think we are going to learn?"

Students either able to questions and there is a relation between question

and their claims better in the following spiral. We found a few problems with writing the procedure cause from the discussion before the experiment, but there is not an important issue.

The observation stage rarely encountered any problems in all spirals. There are only time issues because they spent a lot of time on their experiments and studies, which disrupts the learning process in the next stage.

Explanation stage

The study found in the early spiral the students can't define the claims from the study, the reason is given above in the beginning idea stage. The wrong questioning in the early stage is resulting in incorrect claims. Then after that reflection, students are to improving the learning procedure, the researcher also improved the student's claims by adding a discussion after the study section in a worksheet to encourage students to make their claims easier as shown in the Figure. 4

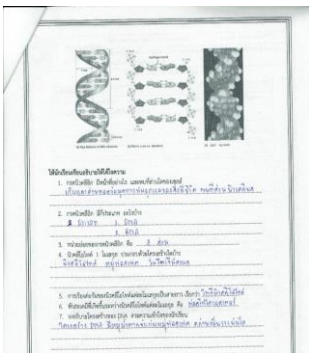

Figure. 4 Example of some discussions

Students have relation between the beginning idea question and their claims. Student's question is "What does the DNA look like?" and their claims referred to the DNA characteristic as follows "DNA has a helix composed of 10 pairs of nitrogenous bases". In the early spiral, students cannot strongly indicate the evidence to encourage their claims, they just only represent what the test result is. Students even cannot record the experimental result a little bit. It leads to incorrect evidence which ultimately could not support their claims. But after updating the learning plans after the spiral ends, learning activities to be more experimented. In the next spiral, students can indicate the evidence better because of the question correctly and provide enough additional details to support their claims.

Students write just only "See from the table", from Unit: Mendelian inheritance, with no sufficient details to support their claims. and after improving (bottom), from Unit: gene pair probability, that students represent in the claims section "the result was 3 type of pairing include red-red, red-blue, and blue-blue calculated according to the minimum ratio of 1: 1.9: 1.1" then the student represents the evidence to support their claims as shown in the evidence

section "see the result recorded 25: 47: 28 calculated according to the minimum ratio of 1: 1.9: 1.1 that approached 1: 2: 1". There is sufficient evidence to support their claims.

Elaboration stage

In this process, knowledge is expanded according to the main concepts of learning through activities such as questioning, exercises, etc. Every spiral has the same problems, time management because students take a lot of time in the previous process, and too much work, therefore, resulting in less time left to manage.

In the reading section, students might compare the concepts that they just discovered by the experiments among friends and the other groups, and other resources. They have to verify their conceptual understanding through the main questions.

The study found the students might not inquire for understanding from other sources but tend to compare their understanding with the teacher text paper. Most students responded with a short answer, hardly explaining their conceptual understanding of the comparison without any details either friends or other references, such sources of reference or referring to differences or similarities. Resulting in insufficient information to create own understanding (Bevins & Price, 2016; Marshall et.al., 2017; Chen et.al., 2018). So, the researcher has improved the section by providing the external resources for students to make it easier to find with the source of references.

Students think about their ideas have changed by looking back on the laboratory activity and the questions in the beginning idea stage (What students have prior knowledge about the questioning?). A part of this may be accomplished in class with group or during the post-lab discussion. Students can then complete the reflection section for the report.

Student's ideas can change through the course of doing their experimental work as the students understand more about the concept they are exploring.

“Changed, because I had never known about the genetic variation.”

“Changed, because I just know the DNA consists of.”

“Changed, because from before, I never known what the DNA was like, but now I understand that the DNA consists of the coagulated ribose sugar.”

Students begin question with “What does the DNA look like?” and prior knowledge is “DNA is a genetic material”. After experiment students reflected in the reflection section is “Changed, because from before, I never known what the DNA was like, but now

I understand that the DNA consists of the ribose sugar paring."

Evaluation stage

Writing the conclusion is the final process. Students will use all the information from the study to summarize the report. In the first spiral, students cannot do well due to the reason that the researcher given in the engagement stage and beginning idea. In spiral 2 and 3, the researcher added the format from the previous stage that supports the students easily write the conclusion with more details.

After improving the research tools in the next spiral, the study found the most students can complete the conclusion section better, composed of claims, evidence, and justification between evidence that encourages the claims (Sung et.al., 2019; Taufik et.al., 2019). Students have science writing at a poor level, they can deduce the learning activity in the early spiral is insufficiency. They may be less an experiment in learning activity, makes the student questions about the beginning idea hardly. Moreover, the beginning idea of the students may be the result of the first stage, the engagement stage. Due to the teacher cannot tell about the content in advance, just only raised a question to engage the students (Chen et.al., 2017; Janna et.al., 2019). Students cannot scope the content and lead confusion about what are they going to learn? From incorrect in the beginning idea question, it leads to failure in the summaries as well. The early spiral, resulting in the lowest students' science writing at a poor level, they need to improve by suitable learning management and some learning skills.

After the reflection, the researcher has improved the procedures in the learning activity to be more experimentation also the question in the first step in the following spiral. The experimental activity is a part of the inquiry learning method based on the concept of constructivist, consisting of learning action (Yaman, 2018). Students create their own knowledge, the claims, through the observation or the questioning to accomplish (Choi & Hand, 2019). Moreover, good questioning at each level helps the teacher known the prior knowledge of their students, ability, engage their curiosity that makes the student willing to participate in the learning activity, and support students to create their own knowledge (Gere et.al., 2019).

However, the experimental activity is a part of the inquiry learning method based on the concept of constructivist, consisting of action that allows student gaining experience directly. It will be more effective than observing or reading documents about the phenomenon

(Shamuganathan & Karpudewan, 2017; Hakim & Meidawati, 2019). But action activities are not always effective in creating meaningful learning. The traditional experiment is investigated to confirm the facts that guidelines are set. The students were not accomplished, because students do not use their meta-cognition to make predictions about what students observed. Thus, science writing heuristic approach has been combined with an inquiry method and used to improve the learning activity that integrates the use of language for learning and argumentation (Keys et.al., 1999; Laux, 2018; Hike et.al., 2020). The inquiry can engage students learn science through in what scientist think and do. It allows students. It provides students with an opportunity to take autonomous learning and creating of what they learn through higher ordered thinking (Kuo et.al., 2019). Inquiry is widely used in science learning management due to its process can allow students think and do like scientists. It has been invited to school science and engage to curriculum, the process of preparation seems to be difficult to teacher (Qodar *et.al*., 2018). Learning environments, learning design, classroom management are important things that teacher should have in professional best. Also, it can help students to enhance necessary skills in the 21st century learning. However, phases of inquiry which used in the study employs 5Es with science writing heuristic.

The 5Es begins *Engagement*, teachers introduce lesson or interested issues to their classroom. Teachers sometimes raise question to their students for preparing students' readiness of learning. *Exploration,* students can create their own knowledge like scientists do by employing process of science and scientific method to explore in what they observed. Students can gain their science communication skills through listening, speaking, reading, and also writing through group working, observing the experiment, taking a note in worksheet, drawing some picture and so on. *Explanation*, it makes science or what they have observed to public through simply understanding. *Elaboration*, students make the relation between prior knowledge with a new experience in what students learned. *Evaluation*, is an assessment of what and how students learned from the lesson (Nuangchalerm & Prachagool, 2019). Students can gain their science writing which teachers designed lesson and also make science to be communicated by science writing heuristic approach. However, students need to be more practiced and learn how write. They have to write in what they know from evidence that scientists make science to be public and communicate

with society (Stephenson & Sadler-McKnight, 2016; Mansour, 2020).

CONCLUSION

The study employed inquiry with science writing heuristic helps students develop a deeper understanding of the big ideas of science contents. The phases of inquiry and scientific writing heuristic approach let student have template/plan, constructing and testing questions, justifying their claims with evidence, comparing their ideas with those of others, and considering how their ideas have changed. Students can learn to communicate based claims and evidences, and also make the both in relation. The final step of the science writing heuristic involves students in terms of writing task. Students often follows a continuous phase of inquiry and step of writing by negotiating and clarifying meanings, explanations with peers and teacher in scientifically. The science writing increased in the following spiral, and the second spiral was the highest level. It could be concluded that students have science writing as well as inquiry with science writing heuristics approach support.

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