The Teachers' Existing Ideas of Enhancing Students' Inventive Thinking Skills

Nophakun Ngaewkoodrua
Faculty of Education, Khon Kaen University, Khon Kaen, Thailand
ngnophakun@yahoo.com

Chokchai Yuenyong
Faculty of Education, Khon Kaen University, Khon Kaen, Thailand
ychok@kku.ac.th

ABSTRACT
This study aimed to explore the science teachers' existing ideas about Inquiry based learning as a way of enhancing students' inventive thinking skills. Methodology regarded interpretive paradigm. The first author participated in the STEM in-service teacher professional development project called the Inquiry based learning workshops of the Thailand STEM Education Project of Chevron Enjoy Science. The first author as participant observer, therefore, would interpret teachers' existing ideas of ways of enhancing students' inventive thinking skills during their participation in the workshop. Key informants 15 females and 5 males who participated in the Inquiry based learning workshops of the Thailand STEM Education Project of Chevron Enjoy Science at Khon Kaen, Thailand. Teachers' existing ideas of ways of enhancing students' inventive thinking skills will be examined through their responding on the checklist about the five essential features of the Inquiry based learning NRC (2000) and their sharing ideas on the open-ended questions about inquiry based learning and enhancing inventive thinking. The results of this study to be the evidence support the researchers' belief that the number of Thai teachers hold some understanding of the inquiry based learning which could be developed some more ideas of organizing learning activities for enhancing the students' inventive thinking skills.

Keywords: Inventive thinking skill; Inquiry based learning

INTRODUCTION
Science and Technology are critical to the daily lives of humans and to be the role in the creation of many things for convenience and to meet the basic necessities of life (Abdullaha and Osman, 2010). Science and technology can foster creativity on various aspects of the creative itself (Sokol, Oget, Sonntag and Khomenko, 2008). Including, the Inventive thinking is considered to have a relationship and a very important mechanism in the development of scientific knowledge and technology in this century (NCREL and Metiri, 2003). The invention and creative innovation benefit to science and technology as well (Williams and Yang, 1999).

In this 21st century, young generation of students require special multiple skills (Abdullaha and Osman, 2010) in order to succeed in their workplace because of the growth of the world is going incredibly fast. So that young students who will be the smart generation must to be the many sets of special skills were prepared and practiced for work and life in the future (Abdullah and Osman, 2010). People who are markers in the new Economy are rewarding those who have high educational achievement and multiple skills. The key word of this is the multiple skills as the Inventive thinking skills.

NCREL and Metiri (2003) stated that the Inventive thinking is one of the important skills for citizens in the 21st century and includes six elements are followed: the first element is the ability to *Adapt and manage complexity*. Secondly is *Self direction* refer to the ability to set goals related to learning, plan for the achievement of those goals and independently assess the quality of learning and any products that results from the learning experience. The third is *Curiosity*. The fourth is *Creativity* is consists of four items as Fluency, Flexibility, Originality and Elaboration. The Fifth is *Risk taking.* And lastly, *is the higher-order thinking*. Consequently, 21st century education should equip students with this skill by moving from primarily measuring discrete knowledge to measuring students' ability to think critically, examine problems, and gather information, collaboration communication, creativity and innovation required for success in their future. Therefore, educational systems must transform their objectives, curriculum, pedagogies, and assessments to help all students achieve the outcomes required for a prosperous, attractive lifestyle based on effective contributions in work and citizenship.

To support students the multiple skills as the inventive thinking skills, teachers may provide variety of teaching styles for inquiry learning. The levels of inquiry based learning are the students' center learning that is the best way to bring the students in line of promotes the students' inventive thinking. It can encourage students to develop advanced skills including inventive thinking skills. The students could describe their own thinking (Loh et al., 2001). It may take several techniques or strategy in order to enable students to learn the essential features of inquiry (NRC, 2000). In order to the open inquiry is to enable students to learn in this process. Students must to have basic skills gained from the training routine before. And they require multiple skills of mental or cognitive skills required (Ural, 2016).

As the part of a professional development called the Inquiry based learning workshops of the Thailand STEM Education Project of Chevron Enjoy Science, the first author participated in the workshop as a trainer who organized the workshop across the nation. This project suggested us the plausibility of enhancing teachers who participated in the project to develop their knowledge and skills to support students' inventive thinking skills. Therefore, we need to develop the framework of strategies imply ways to facilitate teachers' knowledge of how to teach science and enhancing students' inventive thinking. To develop guideline to monitor the understanding of teachers' knowledge, beliefs, and actions, their existing ideas about enhancing students' inventive thinking skills need to be examined.

METHODOLOGY

Methodology regarded interpretive paradigm. The first author participated in the STEM in-service teacher professional development project called the Inquiry based learning workshops of the Thailand STEM Education Project of Chevron Enjoy Science. The first author participated in the workshop as a trainer who organized the workshop across the nation in order to enhance teachers to understand the concept of STEM education. The science teachers who participated in this project may hold some exiting ideas about ways of enhancing students' inventive thinking skills. The first author as participant observer, therefore, would interpret teachers' existing ideas of ways of enhancing students' inventive thinking skills during their participation in the workshop.

Key informants

The 20 volunteer key informants who attended the Inquiry based learning workshops of the Thailand STEM Education Project of Chevron Enjoy Science. The 20 key informants, including 15 females and 5 males who have highest score based on the criteria that are the behavior, curiosity, action and interaction as active learner for attending in the workshop, participated in the workshop at Khon Kaen, Thailand.

The Inquiry based learning workshops

The Inquiry based learning workshops of the Thailand STEM Education Project of Chevron Enjoy Science provided some of essential features of inquiry based learning checking by the criteria that focused on the behavior, curiosity, action and interaction as active learner. The activities provided some views which represent the structure of Inquiry based learning. The activities emphasize that how to choose the appropriate methods in order to enhance inquiry process. Group of four has been used to divide students into a small group and clearly see their duty and responsibility in their own group. Think-pair share has been used to encourage students' writing effectively such as express key ideas, taking a note, using a sign. It can also help both students and teachers to recheck students' prior knowledge, to represent the deep understanding of the data using graph or graphic or diagram. Gallery walks has been used to help students communicate their understanding with other. Formative assessment has also been used as the tool in evaluating students' knowledge. These workshops have been running for a year on April and October 2015. Regarding on teachers' participation on the inquiry based learning workshop, they may hold knowledge and belief related to enhance students' inventive thinking. Taylor and Fratto (2012) argued that students who hold inventive thinking could be able to person who have inventive thinking can solve the problems in a real situation compliance with for learning skills in the 21st Century. The inquiry skills will request the inventive thinking skills. Teachers who perceived some teaching strategies for inquiry based learning may hold some existing ideas about enhancing students' inventive thinking.

Method of inquiry

Teachers' existing ideas of ways of enhancing students' inventive thinking skills were examined through their responding on the checklist about the five essential features of the Inquiry based learning NRC (2000). And, teachers' sharing ideas on the open-ended questions about inquiry based learning and enhancing inventive thinking will be interpreted as their existing ideas about enhancing students' inventive thinking skills.

The checklist questionnaire was developed based on the analysis of the five essential features of the Inquiry based learning NRC (2000). There are 12 items as shown in the Table 1. Key informants have to checklist (correct, incorrect, and no ideas) on the 12 items of inquiry based learning inquiry. Their responding on the

checklist may represent how they understand the essential features of inquiry based learning. Then, participants were further probed in order to give reasons on their checklist. Their reasoning will be categorized to represent their understanding about inquiry based learning.

Teachers' existing ideas about enhancing students' inventive thinking were also interpreted when they participated in the workshop. They shared some ideas on the open – ended questions about teaching strategies during the workshop. They have to share their some ideas of providing learning activities for inventive thinking. There are two items of questions that teachers need to answer; 1) What are teaching methods that can be as Inquiry based learning?; 2) How to develop and enhance the students' Inventive thinking?These could represent what they had existing ideas about enhancing students' inventive thinking as showed in the Table 2 and 3.

FINDINGS

The teachers' existing ideas were examined in three aspects. These included (1) understanding on inquiry based learning, (2) teaching methods regarding on the inquiry based learning, and (3) enhancing students' inventive thinking. Each aspect will be discussed as following.

Teachers' understanding on inquiry based learning

This section aims to find some teachers who hold some of essential features of inquiry based learning. The result showed that all participants have gained deep understanding of inquiry based learning as shown in Table 1.

All participants have experienced in participating in the inquiry based learning workshop. After finish workshop, participants completed the questionnaire about inquiry based learning. Their responding revealed that they perceived the 5Es as inquiry based learning. However, it seems that they hold objectivist perceived about inquiry based learning when they tried to remember the stages of 5Es rather than seeing it as an approach. Below are some of their ideas about.

> *Firstly, item 2 as "5Es learning process (5 steps of inquiry based learning including: engagement, exploration, explaination, Elaboration and Evaluation) is the best Scientific Inquiry." 5Es model is the best strategy of inquiry based learning that is the answering from their idea. They are certain that 5Es is Inquiry based learning. But I still not judge their understanding. There are more evidences below to concern about this data.*
>
> *Teaching by using 5Es, there are five stages and it always beginning by science problems. The way to seek the answering that look like inquiry based learning…" (Nida, interview 2015)*

These 20 participants' answers led we concern that the participants be able to consider the key components of inquiry process which one is important. Based on the reason they gave as "The learning activity begin from the science problems…" that is the one of essential feature of Inquiry based learning. Thus, we do not judge that they are misunderstanding about inquiry because they can classify the essential features of Inquiry based learning. These participants needed to be considered that how they understand the relationship between the 5Es and Inquiry based learning.

Table 1: The percentage of teachers' understanding of Inquiry based learning from interviewing of 20 participants.

	Items	Correct (%)	Incorrect (%)	No idea (%)
1.	Scientific Inquiry is a learning process to develop science process skills while practicing as a scientific activity, which means that scientists use.	90.24	4.88	4.88
2.	5Es Learning process is the best Scientific Inquiry.	26.83	65.85	7.32
3.	Scientific Inquiry focuses on the ability to use scientific skills and scientific concepts.	82.95	12.20	4.88
4.	The Inquiry was held to just try to get results based on theory only.	11.22	82.95	2.44
5.	Scientific Inquiry explained the methods of teaching science group to train students to find answers and develop a scientific understanding of science concepts.	90.24	4.88	4.88
6.	Teacher using the questions to students be considered in the top of level of Inquiry.	48.78	48.78	2.44
7.	Teachers just spend time talking and lecturing more show that these are the open inquiry learning level.	9.76	78.05	12.20
8.	Experimental design in classroom by using the same both of method	24.39	68.29	7.32

	and the conclusion of result as the open inquiry learning level.			
9.	Teaching only one unit the Science Conception should be used to teach the same to the entire unit, because it is the best way to teach it.	2.44	87.80	12.20
10.	The project-based learning as similar as open inquiry learning.	90.24	0	9.76
11.	As a matter of fact, the students' learning in the classroom with the Scientific Inquiry in a variety of ways, such as teaching methods by POE (predict - Observe and Explain) and analogy.	95.12	2.44	2.44
12.	The Students' prior knowledge, behavior, cognition and also learning Media are not influence to the management of Scientific Inquiry learning.	36.59	56.10	7.32

Secondly, item 6 as "The way that teacher asked the student is considered in the top of Scientific Inquiry", asking students a question is highly inquiry. Shown that using the questions to students in classroom lead them to the top of inquiry level. Half of them believe that, while half of participants disagree with. There is teachers' perspective that supported these data.

> "*Using the challenging questions can enhance students' Inquiry, especially, opened-end question.*" (*Sompong, interview 2015*)
> "*Using the questions cannot help students reach the inquiry, it depend on other factor and needs more supporting.*" (*Sunee, interview 2015*)

However, all participants have learned that it needed to seek more factors influent inquiry. Which question lead students into the inquiry that considering. Thirdly, item 8 as "Experimental design in classroom by using the same both of method and the conclusion of result as the open inquiry learning level", same experiment setting in laboratory providing students but end up with the different conclusion that can be an open inquiry. There are 24 percents of participants that agree with.

> *"Inquiry has a fix pattern and need to follow the same stages. The activities have already set up as recipe" (Nongluk, interview 2015)*
> *"…There is no different of each level of inquiry." (Precha, interview 2015)*
> *"The answer is already fixed, it cannot be other answers" (Weena, interview 2015)*

Based on the reason given above, it seemed that some teachers misunderstand some points about inquiry. Lastly, item 12 as "The Students' prior knowledge, behavior, cognition and also learning Media are not influence to the management of Scientific Inquiry learning." , these factors including students' prior knowledge, behavior, material and students' intelligent do not influence to inquiry based learning. There are 37 percents of participants that agreed with.

> *"All students can learn and gain knowledge at the same level..." (Aree, interview 2015)*
> *"If the inquiry activities have been organized well, there is no factors influence..." (Jinda, interview 2015)*

Obviously, this evidence confirmed that some teachers misunderstood about inquiry based learning. It is because these factors including students' prior knowledge, behavior, material and students' intelligent have direct and indirect effected in order to design and create the activities suit with students. In generating and bringing the inquiry activities into the classroom, these factors are key components concerned for teachers. Conclusion, all science participants who hold some of essential features of inquiry based learning (NRC, 2000) from the checklist questionnaire with short answers as a tool. Some of misunderstandings that I mentioned need to explain and fulfill their idea.

Teachers' existing ideas on teaching methods regarding on the inquiry based learning

During the workshop, teachers have shared their perception of teaching methods regarding on the inquiry based learning. It found that their ideas could be categorized into 7 different ideas. These included 1) Starting by Science Problems, 2) Creating the product, 3) Group or team leaning, 4) Focused on Scientific Experiment, 5) Using the mind mapping, 6) Using the science show activities, and 7) Using the multiple methods.

Table 2: The patterns of teaching methods for Inquiry based learning.

Types of teaching methods	frequency (N)	Percentage
1. Starting by science problems	7	25.96
2. Creating the product.	6	22.21
3. Group or team leaning	6	22.21
4. Focused on scientific experiment	5	18.52
5. Using the mind mapping	1	3.70
6. Using the science show activity	1	3.70
7. Using the multiple methods	1	3.70
Over all	**27**	**100**

Twenty six percent of participants asserted that starting by science problems seemed to be Inquiry based learning. Both of focusing to create product and groups or team learning was selected by twenty two percent of participants. There are some dialogs based on the interview supported these data:

> *"Beginning by using the real problems (Scientific problems)" (Weena, interview 2015)*
> *"Dividing students into a small group and working together" (Nida, interview 2015)*
> *"Beginning by using the problem, students need to take their responsibility in their duty as member (Nongluk, interview 2015)*
> *"Students have learned by doing based on the evidence supported*
> *"Students learned by hand on activity" (Jinda, interview 2015)*

Some participants supported that in different ways.

> *"Teaching by using mind mapping makes my students gaining deep understanding" (Juntra, interview 2015)*

Based on these reasons, we do not see involving between teachings by mind mapping and inquiry based learning, so it needed to seek more evidence.

> *"Science show can encourage students' interest" (Suri, interview 2015)*
> *"Using various teaching strategies can enhance inquiry based learning" (Nalinee, interview 2015)*

These reasons are rather weak to support the inquiry based learning. Teachers, who have experience for teaching science less than 5 years and they did not graduations in science major, explained teaching strategies as mind mapping and multiple methods without linking to science content and skills. The science teacher who answered as using science show activity is not clear what exactly the main aim of this teaching style. It indicated that they could not recognize to scientific inquiry as way of knowing science. The science show activity just is the activity beginning to encourage students wonder or might be curious students in science concepts. And also, in the creating the science question, the science show may help students to do this but science teacher must to aware inquiry based learning is consisted of 5 essential features for students learn through all of items (NRC, 2000). The last science teacher just gave the answer as "Using various teaching strategies can enhance inquiry based learning" but she cannot explain more details how to use the various strategies to teach science and enhance inquiry based learning. Then, when talking to the essential feature of the inquiry based leaning, they still be confused and could not explain the detail of essential feature of the inquiry based leaning too.

Teachers' existing ideas on enhancing students' inventive thinking

The 20 key informants were interviewed what their ideas about teaching strategies for enhance students' inventive thinking. It found that they raised 8 teaching strategies as in Table 3. According to the Table 3, teachers provided eight groups of enhancing students' inventive thinking. These included teaching based on science technology and society (STS) approach, problem based learning, project based learning, open – ended question, co – operative learning, focus on ICT tools, scientific method and learning by doing. Interestingly, the STS approach, problem based learning and project based learning were high recognized among them.

Table 3: The teachers' ideas of teaching strategies for enhancing the students' inventive thinking skills.

Types of teaching strategies	frequency (N)	Percentage
1. STS approach	5	23.81
2. Problem based Learning	5	23.81
3. Project based Learning	4	19.06
4. Open – Ended Question	1	4.76
5. Co – operative Learning	1	4.76
6. Focus on ICT tools	2	9.52
7. Scientific method	1	4.76
8. Learning by doing	2	9.52
Over all	**21**	**100**

Both of STS approach and problem based learning have been answered as the same percents were twenty four, whereas nineteen percents of participants answered focus to the project based learning. These are some of ideas that they represented as:

> *"I think, STS approach is interesting because it may begin the local problem based on the context and closely to us or our environment problem around us. It means to us a lot if we can solve our problem by ourselves. It might to promote the science students' higher skills" (Suda, interview 2015)*
> *"Social problem based on STS approach can be used to be as real opened-ended question which lead to the open inquiry" (Malee, interview 2015)*

From the Suda and Malee's idea said, they focused to the Context based is the one of features of the STS approach might enhance the Inventive thinking skills. Another dialogue which some teachers represented about the problem as below:

> *"The process of solving the problem need various skills in order to discuss and synthesis the best way. It needs to promote the higher order thinking and also the Inventive' thinking skills too." (Suri, interview 2015)*

To sum up based on the reason given by participants, most of them focused on the local problems around students. Context based was talking in the leaning. Students may learn through their problems that make a meaningful in their life and social. Students may relate scientific knowledge into daily life that can go together and may enhance the Inventive thinking skills of students also.

DISCUSSION AND CONCLUSION

The most of participants gain deep understanding in the meaning of inquiry and also be able to synthesis the essential features of inquiry based learning which themselves. They perceived some of essential features of inquiry based learning checking by the criteria that focused on the behavior, curiosity, action and interaction as active learner. They can design and choose the appropriate methods into the classroom in order to enhance students' inventive thinking skills. Approximately, 26 percentages of participants selected the Starting by Science Problems as the ideas of enhancing students' inventive thinking. And, 26 percentages of participants selected the STS approach and Problem based learning. This is good sign of teachers' existing ideas because literatures Miri, David, and Uri, 2007; Madhuri, Kantamreddi, and Goteti, 2012) stated that fostering inquiry based learning was a good chance for higher skills also the dealing in class with context based.

It could be mentioned that teachers perceived the context based inquiry such as Science, Technology and Society (STS) to provide students' inventive thinking. Science, Technology and Society (STS) is an approach for Inquiry based leaning style which might be the best way to promote the students' Inventive thinking skills. Moreover, it found that knowledgeable teachers and skillful teachers in inquiry based learning, be able to design various activities and be able to apply it into the classroom. Teachers who had experience in participating in the inquiry based learning workshops able to design a various activities and be able to apply it into the classroom. It might be the merging inquiry based learning and STS approach in order to enhance students' inventive thinking (Barrow, 2010). This suggests that the guideline to monitor the understanding of teachers' knowledge, beliefs, and actions of enhancing students' inventive thinking skills need to be developed regarding on those of their mentioned about inquiry based learning approach and STS approach.

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