

Full Length Research Paper

Empowering Lower Secondary Students Through Scientific Reasoning

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In this era, society needs young students to think and do what they should do in the 21st century. This research aims to promote reasoned argumentation in science for lower secondary students, which is relevant to prepare citizen in a world of change. The participants in this study were 33 lower secondary students. The findings found that instructional practices which promote reasoned argumentation as "CRABS MODEL"; they are choosing issue; reasoning; argumentation; brainstorming and summary. This can make students to have higher thinking in argumentation. Students could develop the reasoned argumentation by using problem analysis process, data gathering and reasoning, facts and opinions classification through argument, brainstorming of various choices and summary, which are higher than pre-test at the statistical significance level of 0.05.

Key words: instructional model, argumentation, reasoned argumentation, pedagogy, science education, thinking, Thailand.

INTRODUCTION

Preview studies in the past decade (year 1999-2008) after the promulgation of the Thailand Education Act of 1999 found it necessary to rectify the major problem of students, which is quality. The educational assessment indicates that scores of the students derived from international agencies such as the International Institute for Management Development (IMD), Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) are low. Also, the ability of the students is low compared to international criteria. The PISA assessment focuses on critical thinking and explanation using multiple choice and written answers. The PISA test is in the form of a variety

of situations involving in real life and the local situation of a country or the world at large. Students must be able to answer all scientific questions sensibly. The PISA tests assess students' abilities in three areas: scientific phenomena, evaluation and design process of science inquiry and interpretation of scientific data and testimony. In PISA, Thailand is ranked 50 out of 65 member states. In the second round of the external assessment, of the fiscal year 2006-2008, schools in the whole country need to improve their area of thinking such as analytical thinking, synthetic thinking, creative thinking and critical thinking (Office of the Education Council, 2009). The Core Curriculum for Basic Education Act 2008 defines

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learning as a cognitive science, skills or learning process desirable to all students. Basic education is the knowledge and scientific process used to study knowledge and solve problems systematically. If students' ability in science is not reduced, it will help in the development of the course. Science is a culture of the new world, a knowledge-based society where everyone needs to be infused with science knowledge. This will make them understand nature and human-created technology and be able to utilize the knowledge with rationality, creativity, and morality (Ministry of Education, 2008).

Argumentation in science education delivers a good quality of science classroom; this can be promoted based on decision (Dawson and Venville, 2008). This is vital for starting science discussion (Hanegan et al., 2008) and also socio-scientific issues in the classrooms (Jiménez-Alexandre et al., 2000; Erduran et al., 2004; Osborne et al., 2004; Kolsto, 2006; Simon et al., 2006). Furthermore, science argument promotes science literacy and relates to scientific community in classroom. Moreover, students are not only taught by using books, photos or computers, but they actually need the critical thinking process to develop their science skill and confidence (Driver et al., 2000).

Newton et al. (1999) explained some reasons about science debate in science classroom context with explicit teaching in science classroom; they refer to: 1) scientific knowledge debate is the process of science knowledge development which can be practiced as science discourse; scientists develop the proposal and search some evidence by monitoring the debate, reviewing and criticizing the scientific communities (Nuangchalem, 2009-2010). Therefore, science knowledge process should be started from students' debate. The students need to understand and be able to develop their knowledge in the future; 2) the engagement can be done by debating, which represents students' understanding by using activities to represent information of how students understand their science lessons. This will help their attitude in decision making regarding science issue, including their conceptual understanding; 3) debate skill is more powerful than the usual science learning because it helps the learners to have critical thinking, to be reasonable and logical; this is related to the written and spoken presentation in the society. It has positive outcome for democratic society (Newton et al., 1999). Also if science teachers understand science argument, they can apply it to their classroom teaching, which will be more effective in helping students in their learning. Moreover, teachers need to develop their science debating, which is combined between informal reasoning and formal argumentation. Thus, they need to support the students' debate in the class as well (Sadler and Zeidler, 2005).

Science is not only about learning scientific information, but it is also critically understanding how to search for all evidence and the reasons for supporting comprehensive

arguments (Toulmin, 2003). Therefore, developing students' thinking strategy is important in terms of science knowledge base (Toulmin, 2003; Yore et al., 2007). This has benefits and drawbacks in students' arguments (Walker and Zeidler, 2007). Effective strategy helps the students to receive reasonable arguments. This also encourages students to evaluate their thinking skill, boost their confidence and work on teamwork situations, including understanding the value of group members' background differences.

Furthermore, the activities of teaching that encourage students to practice thinking and argue rationally in classroom discussions on problems in today's society are involved with the effects of scientific technology on human, society, nation and the environment around us. These activities cause the students to think critically about the effects of science and technology on problems in the society (Bodzin and Mamlok, 2000). This is because improving the quality or ability of learners is a complicated process of reflective thinking, and to think rationally requires the proper elements to support the ideas to decide whether to believe or not and how to do it (Zoller, 1999; citing O' Tuel and Bullard, 1993).

Socio-scientific issue is a word representing current dilemma issues caused by contradictive opinions, principles and problems, that are rooted from science and technology knowledge (Kolsto, 2001; Zeidler et al., 2002; Nuangchalem, 2009). They are issues that people in the society do not agree with their principles and methodologies, and this affects the various aspects of the society, such as social, economy, religion, morality. The severity of each issue varies depending on the differences of each society and culture (Sadler, 2002; Sadler and Zeidler, 2003). People nowadays have an opportunity to encounter socio-scientific issues more frequently as they are allowed to express their opinions and be part of social decision making more than they were in the past. It is therefore essential for people in democratic society to be well prepared so that they would express their opinions with reason and evidence to support their argument (Kolsto, 2001). Currently, socio-scientific issues are used as discussion topics in science classroom (Nuangchalem and Kwuanthaong, 2010). Students are taught to find solution to unsolved real socio-scientific issue that exists in their community so that they can relate what they learn in classroom to their daily life issues. This makes science classroom meaningful and relevant to real life (Sadler and Zeidler, 2003).

Today, science and technology plays a main role globally. Therefore, it is necessary that students be taught how to apply science knowledge from classroom activities to real life situations, such as transferring science knowledge to the public debate. Learners should always be knowledgeable and have balance in making decisions for socio-scientific issues in daily life (Dawson and Venville, 2008). Thus, the main point of making a good science classroom is preparing learners to be ready

for all issue. They need to learn how to make quick decision and solve sudden problems, because learners' thinking process can be evaluated by evidence and informed decisions. Therefore, it is important for teachers to develop teaching methodology to support students' learning which can be applied in debating and socio-scientific issues (Sadler and Fowler, 2006).

Socio-scientific issues for science classroom management are necessary in teaching process. This is because science teaching techniques need to be understood by learners. The learners can also employ all knowledge in terms of applying their science lesson to reality situations. Furthermore, critical thinking process is an efficient practice for learners, particularly when they receive some daily society issues, and they can apply this long term knowledge to face and solve all problems in each situation. This paper aims to promote reasoned argumentation by adopting socio-scientific issues in science classroom. Students can implement what they learn in classroom to their daily life, which is a desired outcome for people in democratic society.

METHODOLOGY

The research was conducted through a methodology and development process, divided into 3 phases.

Phase 1: Contextual study

We study the contexts, current conditions, theories and related research on science instruction to promote reasoned argumentation by non-participants' observation in science classroom and semi-structured interview instructors. The samples of this step consisted of 15 schools. Non-participant observation consists of four areas: 1) The atmosphere of the classroom, 2) education instruction arrangement, 3) Posing a question to the teacher and 4) Questions and answers of the student. The data collection tool, non-participant observation and also videotapes for recording science classroom activities are described. The semi-structured interview on learning activities is centered on five topics 1) method for teaching (lecture, assignment, reading, presentation project and discussion etc.), 2) method that encourages the interest of the students, 3) method for choosing the substance or issue in the instruction, 4) method of reinforcement and 5) other suggestions. The data were collected by interviews in each issue.

Phase 2: Tentative model

Researchers synthesized science instructional model to promote reasoned argumentation which summarized the data of the contextual study and also supported the theoretical background. Then, the instructional model was assessed by its appropriateness and validity by seven educational experts. Tentative model was conducted with a total of 30 students who were not in the sample group. An analysis of relevant documents, textbooks and research studies was done to build a base for further development of the instructional model in form of qualitative research. It has the following as its important elements: Principles and basic conceptual theories, Purpose, Syntax (Step 1: Choosing issue, Step 2: Reasoning, Step 3: Argumentation, Step 4: Brainstorming and Step 5: Summary), Social system, Principle of reaction and Support system.

Phase 3: Implementation the instructional model

The science instruction for promoting reasoned argumentation was test two times in order to develop instructional manual. The samples of this step consisted of 6 students in the first trial and 18 students in the second trial. The data were collected in this phase and then classroom phenomena and some behavior of the students were recorded with videotape. Finally, the instructional model was developed for 33 lower secondary students, in the first semester of the academic year 2014. The result analysis of instructional model was evaluated by a questionnaire and a test. The result can be explained as mean scores of reasoned argumentation between the pre- and the post-experiment were compared with independent t-test.

RESULTS

This research aims to develop science instruction to promote reasoned argumentation and develop lower secondary students. The research and development process consists of three steps: 1) contextual study 2) tentative models, and 3) implementation of the instructional model. The experimental results can be explained as follows.

In the contextual study phase, it is found that students can search scientific knowledge to use it for argument, discourse, debate, review and to criticize including conceptual understanding. In the study, it is concluded that teaching consists of five aspects: 1) the theoretical principles which are fundamental for the development of teaching, 2) objectives of teaching, 3) the process of learning and teaching, 4) how to measure and evaluate the user in the teaching form and 5) to explain or provide information about the methods and techniques of teaching that will help performance of the teaching process. Next phase is tentative model; the instructional model had high level of appropriateness. Upon developing the science instructional model to promote reasoned argumentation, there were six elements; principles and basic conceptual theories, purpose, syntax, social system, principle of reaction and support system. The science instruction for promoting reasoned argumentation comprised the five stages named "CRABS MODEL" (C-Choosing issue, R-Reasoning, A-Argumentation, B-Brainstorming and S-Summary). In the last phase, implementation of the instructional model, it is found that the researchers developed the instructional model for use in further tests.

The result of using science instruction to promote reasoned argumentation found that students could develop process reasoned argumentation in terms of problem analysis process, data gathering and reasoning, facts and opinions classification through argument, brainstorming of various choices, and summary. The result can be explained as mean scores of process reasoned argumentations shown in [Table 1](#).

The test used in the evaluation of the instructional model, as shown in [Table 1](#), showed the achievement of promoting reasoned argumentation model in teaching at

Table 1. Reasoned argumentation of lower secondary students.

Item	$\bar{X}$	S.D.	Level of reasoned argumentation
1. Read and understand the problem before identifying issues	4.15	0.76	High
2. Confident in expressing their opinions	4.06	0.66	High
3. Analyze and understand current issues	4.15	0.67	High
4. Identify the problems of scientific and technological knowledge to use	4.18	0.73	High
5. Reasoning the different reasons, open to listen to other people	4.18	0.64	High
6. Have the ability to collect data related to identify problem	4.21	0.60	High
7. Study more knowledge to give reasons for the argumentation acquiring knowledge	4.15	0.71	High
8. Confidence in reasoning to argumentation from source data	4.06	0.61	High
9. Consider the source and reliability of the data	4.21	0.60	High
10. Identify facts and opinions	4.12	0.70	High
11. Consider and evaluate alternative possibilities of the issues with others	4.09	0.68	High
12. Summary based on facts or reliable data source	4.18	0.58	High
13. Listen to the arguments and reasoning of others	4.09	0.63	High
14. Compare the arguments and reasons together	4.06	0.70	High
15. Get the new reasonable conclusion	4.03	0.77	High
Total	4.13	0.67	High

Table 2. Comparison of the mean scores of reasoned argumentation before and after using the development model.

Item	n	$\bar{X}$	S.D.	t	P
Reasoned Argumentation	before	33	6.73	1.008	15.518 0.000
	after	33	11.76	1.458	

a high level. The overall average was 4.13 and the standard deviation was 0.67. Level of reasoned argumentation was high, with an average of 4.21; students are able to identify problems in this research by supporting reasoned argument.

Table 2 shows that the students have reasoned argumentation post-test higher than pre-test at the significance level of 0.05 .

DISCUSSION

The teaching and learning activities focus on students as the vital part, as well as teaching the students to learn by practice and participating in searching for the correct answers. They can also apply the learning methods to their real life situations and the instructor will be their learning support. The ultimate goal is to develop the learners to be complete and consistent with the provision of education for students in the 21st century, which has 5 principles in major learning; authentic learning, mental model building, internal motivation, multiple intelligence and social learning (Trilling and Fadel, 2009). Science and special science classrooms can be considered; if a student has an understanding and is interested in the

content, the student will learn better. Whether the teaching materials are small or large, if they are meaningful to the learners, they will be urged to take more and learn in their classrooms. The role of the teachers, including asking questions and praising the students can motivate them. Students who have done lap activities and presentation in front of the class will be more confident than the others who have not done them.

Moreover, the main point to be considered is when students are successful in their learning in the class in relation to McKinsey's report that describes the vital issues of classroom management: 1) teachers, 2) schools, sources and sponsors, 3) students. However, the differences in science studying are the ability to show the expression of teachers and the confidence to manage the science classroom, including preparing materials for teaching science. There are five major steps in the process: 1) choosing issues 2) reasoning 3) argumentation 4) brainstorm and 5) summary.

Step 1 Choosing issue: Selection of issue refers to the selection that occurs in a society where the students have to choose. The application of socio-scientific issues in the teaching and learning in the science classroom is to be used as a tool to promote learning of science. This

learning is meaningful and consistent with the learners' real life (Sadler and Zeidler, 2003). The principles of teaching are student-centered. The problem-based instruction consists of learners who are able to identify topics that they are interested in. It can be the problems that they face in society or community. Furthermore, everyone in the class also understands the issues with no different levels, so that the problem will encourage learners to seek knowledge in order to eliminate their doubts. When the students face real problems in various situations, they will share the ideas to solve the problems, and this allows learners to gain meaningful and stable knowledge. Moreover, this may deliver the Constructivist Learning Theory, which we believe allows students to recall their previous knowledge and apply it in different situations.

Step 2 Reasoning: *Regardless of students' reasons (Reason oneself).* At this stage, the teaching is focused on the learners (Student-centered instruction). This makes students more active in learning with different activities. This is because the students will learn the most when they have a chance to participate in classes and they will use cooperative learning enthusiastically. The management of cooperative learning encourages learners to learn best, particularly when they share their knowledge with friends. Using the classroom as a social interaction is important to all members in the group. Therefore, everyone contributes with comments and their expressions. If the issue is known or interesting, it will allow the students to understand by recognition because they already stored the information in their memory.

The presenting of stimulus that learners already know or have some information can help students turn attention to it and recognize it. This allows teachers to create new things that relate to the information of the processing theory and gives learners self-esteem. This is very important in building positive attitudes with confidence and positive feeling with the people around them. This includes social and emotional adjustment which learners need to deal with the obstacles in their life. People with less self-esteem have negative emotional reaction. Currently, friends issue, the media environment conditions, cultural background, or social conditions generally make children feel inferior with low self-esteem (Palladino, 1994). Thus, we should develop a positive attitude to learning in the learners and also improve the environment around us to extend a higher self-esteem for students. Furthermore, teachers need to be creativity, which makes students able to face the problems, adapt and live in the society with happiness. Moreover, confidence and assertive training is one approach to develop self-esteem by providing individuals with the opportunity to share their own ideas and attitudes that represent their various needs. This can help learners feel better about them in terms of developing their self-esteem (Alberti and Emmons, 1978).

The other reason refers to an event in which every student finds the answer to each issue. This is because a common approach, which they believe is a solution, has a positive or negative effect on the community. Furthermore, everyone is facing enormous problems in everyday life such as the economy crisis including issues that are difficult to resolve. There are many issues that arise from using science and technology knowledge. However, one thing that is important in the science classrooms is to make the students apply knowledge in the public debate as an expert. They also need to have the ability to decide on the socio-scientific issues that affect their lives (Dawson and Venville, 2008). Thus, in learning science, the learners need to have debate skill about socio-scientific issues (Sadler and Fowler, 2006). In today's world, people face problems which cause them to make decisions at all time. Some problems do not need much time to make a decision, but some problems are very complex, require longer time to think before deciding. Individuals who consider such ethical reasons will decide correctly and thus they and the society benefit.

Step 3 Argumentation: Applying Argumentation in Science Education promotes effective science teaching. This knowledge is based on the proof of evidence in decision making (Dawson and Venville, 2008). It is an important part in the beginning of any discussion (Hanegan et al., 2008). This relates to socio-scientific issues in classroom contexts (Jiménez-Aleixandre et al., 2000; Erduran et al., 2004; Osborne et al., 2004; Kolsto, 2006). Furthermore, the debate in science supports understanding of science literacy and scientific community. In science classroom, students are not only required to listen to their teachers, but they also need to practice their thinking in order to construct their confidence. This is the process of developing their skill to be more familiar and understandable (Newton et al., 1999; Driver et al., 2000).

Step 4 Brainstorming: Brainstorming refers to a process of mutual dialogue to figure out a solution by considering what type of actions that the students need to act both in the past and current experiences. This will help everyone jointly and reveal what others think, get to know and accept the truth in other aspects. Questions can be applied to help make conversations between the students. Thus, they can listen to each other and share their own experiences in the group.

Step 5 Summary: Summary refers to the concluding step which brings the other people's feelings after the brainstorming to find a solution to the problems. This step requires everyone to talk about their opinions, open their mind to others and make a presentation in front of the class by using everyone's idea from their chatting (Nuangchalerms, 2012).

It is concluded that science instruction that promotes

reasoned argumentation has 6 components including principles and basic conceptual theories, purpose, syntax, social system, principle of reaction and support system which is called "CRABS MODEL" ; choosing issue; reasoning; argumentation; brainstorming and summary. Students could develop the reasoned argumentation in terms of problem analysis process, data gathering and reasoning, facts and opinions classification through argument, brainstorming of various choices, and summary.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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