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Research Article

Exploration of Trend and Patterns of Scientific Argumentation in Science Classrooms in the Thai Context

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Abstract: This research aims to explore the studies of student scientific argumentation and the patterns of grade 10 student argumentation in science classrooms in the Thai context. The researchers reviewed 14 studies related to student scientific argumentation and observed one grade 10 science classrooms in Khon Kaen province, Thailand, to explore the patterns of student scientific argumentation. The teacher-student and student-student discourses are coded and categorized by using the Toulmin Argument Pattern (TAP) framework. The findings revealed that there was a lack of studies related to the exploration of patterns of student scientific argumentation. In addition, there was a lack of high-quality pattern of grade 10 student scientific argumentation in the science classroom. These findings urge a study to explore student scientific argumentation and to design a teaching and learning strategy to promote student high-quality scientific argumentation.

Keywords: Scientific argumentation, science classroom, quality education, grade 10, Thailand

Introduction

The wave of national education reform had been originated in 1999 from the proclamation of the 1999 National Education Act (B.E. 2542) (Office of the National Education Commission, 1999) that was later revised as the Amendments (Second National Education Act B.E. 2545) in 2002 (Office of the National Education Commission, 2002). This educational reform emphasizes the student-centered learning process where students are regarded as the most important part. Regarding the constructivist teaching and learning, the teaching and learning process shall aim at enabling learners to develop themselves at their own pace and to develop with their full potential. Educational institutions and agencies shall provide training in thinking process, management, how to face various situations and application of knowledge for obviating and solving problems. Up to this, the ultimate goal of education aims at developing Thai citizen to cope with the economic, social and political growth of the countries in the ASEAN region.

Even though the Ministry of Education (MOE) has been emphasized the student-centered teaching and learning process in Thailand since 1999, the teaching and learning process in some classrooms still focus on teacher-centered. The goal of teaching is to make students acquire good scores in school exams and, ultimately, in the Ordinary National Education Test (ONET). To get that, many students focus their learning on memorization of contents rather than practice an ability to critically think, logically analyze and systematically solve real problems. Also, there are a few connections between students' learning scientific knowledge and its application in their daily lives. This situation is not

good for the growth of Thailand because the students in basic education will serve as a future human resource for the nation and Thailand hopes them to grow and become the quality Thai citizen (Office of the Education Council, 2011).

Regarding science teaching and learning, the new science curriculum emphasized science teaching and learning to be based on scientific inquiry. The students who learn with scientific inquiry are required to construct knowledge by themselves through scientific inquiry process. In the scientific inquiry process, one important part is scientific argumentation (Berland & Reiser, 2009). There is a relationship between the scientific argumentation skill and scientific understanding. In a science classroom, students are encouraged to utilize their scientific knowledge and cognitive process to generate their scientific argumentation. The students, then, are required to participate in a social process to communicate their arguments as well as exchange and defend them with others in the science classroom. Thus, promoting scientific argumentation through scientific inquiry classrooms is, therefore, regarded as one important goal in science teaching and learning (Sampson, Grooms, & Walker, 2009).

The current science education movement needs students to attain good argumentative skills because there are various social-related scientific issues and conflicts to make arguments on them. This means that students are expected to be able to consider reliable evidence before making decision on the conflict issue. In addition, students should be able to communicate their arguments with their peers who may agree or disagree with them. In an argumentative process, students express their efforts in seeking for reliable evidence to confirm and persuade other side students agree with them (Toulmin, 2003).

From the literature review, there are several studies related to students' scientific argumentation. So, there is a need to analyze these studies to understand the trend of scientific argumentation in Thailand. In addition, there is a need for an in-depth study to explore the patterns of students' scientific argumentation in a science classroom in the Thai context. The findings from these queries may lead to better understanding about what should be studied in the science education context in Thailand and what should be encouraged to promote in science students in order to help them attain good scientific argumentation skill. Therefore, the research questions of this study are: a) What is the trend of studies related to students' scientific argumentation in Thailand? And b) What are the patterns of grade 10 students' scientific argumentation in a science classroom context in Thailand?

The objectives of this study are: a) to explore the trend of studies related to students' scientific argumentation in Thailand; and b) to explore the patterns of grade 10 students' scientific argumentation in a science classroom context in Thailand.

Literature Review

This section presents the review of literature related to the national science education reform in Thailand and scientific argumentation.

2.1 National science education reform

In the Thai context, the second pave of national science education reform had been started in 1999 from the announcement of Constitution of the Kingdom of Thailand (B.E. 2540). Later, the Ministry of Education had announced the National Education Act B.E. 2542 that led to the proclamation of the new national curriculum--the Basic Education Curriculum B.E. 2544 (Ministry of Education, 2001). In this new national curriculum, the learning subjects had been divided into eight learning areas; science was one among them. The science learning area aims to enable learners to link scientific knowledge with processes, acquire essential skills for investigation, build knowledge through investigative

processes, seek knowledge and solve various problems. Learners are allowed to participate in all stages of learning, with activities organized through diverse practical work suitable to their levels. In the Science Learning Area, there were eight learning strands: Living Things and Processes of Life; Life and the Environment; Substances and Properties of Substances; Forces and Motion; Energy; Change Process of the Earth; Astronomy and Space; and Nature of Science and Technology. There were two new learning strands in this new science curriculum, that is, the Change Process of the Earth and Nature of Science and Technology learning strands.

2.2 Scientific argumentation

Scientific argumentation is one important skill in a scientific inquiry process that the students should attain in learning science. Scientific argumentation is a process or action where a student expresses idea or provides a rationale against the others with supporting evidence. Stephen Toulmin (1958) stated about scientific argumentation in the Toulmin's Argumentation Pattern (TAP) that is consisted of: Ground (Evidence), Claim, Warrant, Rebuttals (Counter argument), Backing (Supportive argument) and Qualifiers. Ground (Evidence) means that the student can use facts or evidence to prove his or her argument. The facts or evidence involved in the student argument aim to support student claim. Claim means that the student thinking of the argument. It is the student's most general statement in the disputation. It is also the student's common principle or affirmation made after student brainstorm in group. Warrant means that the student has the argument consisting of a title versus the claim with supporting data and has warranties or backings having no rebuttals. Warrant is a reason (e.g. rule, principle, etc.) that are proposed to justify the connections between the data and the knowledge claim, or conclusion. Rebuttals (Counter Argument) specify the conditions when the claim will not be true. Rebuttals express counter arguments or statements indicating circumstances when the general argument does not obtain true. Backing (Supportive Argument) is basic assumptions that are usually considered to be commonly agreed. Backing provides justification for particular warranties. Arguments do not necessarily prove the main point being argued but aims to prove that the warrants are true. Finally, Qualifiers specify the conditions under which the claim can be taken as true. Qualifiers represent the limitations of the claim (Toulmin, 2003).

In addition, Sampson, Grooms and Walker (2011) presented the three components of a scientific argument - the Claim (or the explanation), the Evidence (or the observations), and the Rationale (or the reasoning). In essence, scientific argumentation necessitates scientists to substantiate their assertions, whether in favor of or against a specific idea or explanation, by presenting evidence derived from systematic observation or experimentation. Subsequently, scientists employ logic and reason to elucidate how the gathered evidence supports their claims. Unlike beliefs or opinions, which cannot be empirically verified regardless of their intensity, scientific arguments rely on evidence and data. This preference stems from the fact that evidence and data are subject to empirical reexamination and retesting. Acquiring the skill to construct a valid scientific argument is instrumental in discerning unscientific arguments—those grounded wholly or partially in emotion, ignorance, misinterpretation of scientific evidence, or denial. This study employed TAP in analyzing the pattern of scientific argumentation in one science classroom regarded as a case study because TAP can provide more complex components of scientific argumentation.

Methodology

This study employs a case study (Sturman, 1997) to explore in-depth about students' scientific argumentation bounded in the science classrooms in Thailand. A case study has been selected for this study due to its inherent capacity to capture the contextual nuances and lived experiences of participants. There were two phases in this study: a) Review of studies about students' scientific argumentation in Thailand; and b) Exploration of patterns of grade 10 students' scientific argumentation in a science classroom context in Thailand..

Data collection

In the first phase, the researchers searched the literatures related to scientific argumentation from two research databases i.e., ThaiLis (Thai Library Integrated System) and ThaiJo (Thai Journals Online by using two keyword "argumentation" and "science." These studies must be reported during 2014-2018. The studies related to argumentation but being conducted in different subjects were deleted from the final pool. Aft final, the authors came up with 14 studies related to scientific argumentation in Thailand.

In the second phase, the first author conducted classroom observation with one grade 10 science classroom teaching and learning located in urban area in Khon Kaen province, Thailand. This science classroom was chosen as the focal point of the case study because the science teacher within this setting willingly agreed to participate fully in the research. Furthermore, the selection of Khon Kaen province as the study location was motivated by its practical convenience for the first author in terms of data collection. The science teaching and learning of grade 10 science classroom were recorded by using a videotape recorder and a classroom observation schedule. Also, the researchers collected related teaching and learning documents such as student worksheets and products.

Data analysis

The researcher started the analysis process by transcribing the videotape verbatim. The transcriptions of video tapes were sent to the research participates for conducting member checking in order to enhance the trustworthiness of this study. Later, the teaching and learning discourse in the transcriptions were analyzed by using the Toulmin's Argument Pattern (TAP) framework (2003), which consists of Ground (Evidence), Claim, Warrant, Rebuttals (Counter argument), Backing (Supportive argument) and Qualifiers.

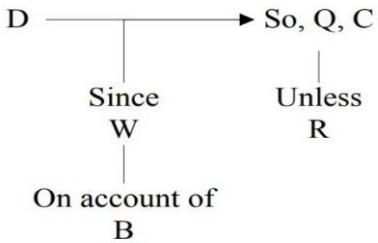

Figure 1 TAP Analytical Framework
Source: Toulmin's Argument Pattern (TAP) framework (2003)

The types of scientific argumentation were coded and analyzed by using the following description provided by Chin and Osborne (2010).

Table 1 Types of Scientific Argumentation

Type of scientific argumentation	Code	Description
1	AC	A simple claim without justification or grounds versus another claim or counterclaim.
2	AG+	One or more claim(s) with simple justification or grounds (comprising data, warrant, and/or qualifier and backing) but no rebuttal.
3	AG++	One or more claim(s) with more detailed justification or grounds (comprising data, warrant, and/or qualifier and backing) but no rebuttal.
4A	AG+R	One or more claim(s) with justification or grounds and with a rebuttal that addresses a weakness of the opposing argument and/or provides further support for one's earlier argument.
4B	AG+RS	One or more claim(s) with justification or grounds and with a self-rebuttal that considers the limitation or weakness of one's own argument.

Source: Chin and Osborne (2010)

The numbers in the codes of scientific argumentation do not hierarchically show their levels. Rather, the numerical order indicates the degree of complexity, within which Type 1 is the most rudimental, while Type 4 is more advanced. On the other hand, in some cases, the hierarchy is less prominent between Type 3 and Type 4 due to the fact that Type 3 may embodies more well-established justifications with more extensive grounds than Type 4, whereas Type 4 may contain a very basic justification yet with rebuttal.

Results and Discussion

The result section is presented into two main subsections in line with the two mentioned research questions in accordance with their discussion.

Trend of studies related to students' scientific argumentation in Thailand

The researchers reviewed 14 studies in the Thai context regarding students' scientific argumentation. The research title and key results are shown in Table 2.

Table 2 Summary of Studies of Students' Scientific Argumentation in Thailand

No.	Year	Author	Grade	Title	Key result
1	2014	Piyachat Chantakua, Rittikrai Chaiyangam and Butsara Yongkhamcha	7th	A comparison effects of learning socio-scientific issues using the mixed methods based on the scientific method and the traditional	The students classified by the high achievement motive students and the low achievement motive students showed the significantly greater improvement of students' argumentation and logical thinking in overall. The high achievement motive students indicated more logical thinking than the low achievement

No.	Year	Author	Grade	Title	Key result
				learning method on argumentation and logical thinking of grade 7 students with different achievement motivation	motive students. In addition, the experimental group evidenced more argumentation and logical thinking than the control group. However, there were no statistical interactions between achievement motivation and learning methods on socio-scientific issues with the students' ability in argumentation and logical thinking.
2	2015	Cholthicha Karnjak1, Jeeraphan Suksringarm2 and Porameth Janpeng3	8th	Comparisons of effects of learning socioscientic issues using the mixed methods based on Lin and Mintzes method and the 5E learning cycle approach on argumentation and critical thinking abilities of Mathayomsuksa 2 students with different science learning outcomes	The students as a whole and a classified according to science learning outcome and learning method who learned using the mixed methods based on the Lin and Mintzes method and the 5E learning cycle approach showed developments in argumentation from the 1st test to the 4th test; and showed gains in critical thinking abilities in general and in 4 subscales from before learning. The students with different science learning outcomes did not show different argumentation and critical thinking abilities in general and in 2 subscales after learning socio scientific issues. But the high science achievers indicated more critical thinking abilities in 2 subscales: credibility of sources and observation and induction, than the low science achievers. The students with different learning methods did not show different argumentation and critical thinking abilities in general and in 3 subscales after learning socio scientific issues. However, the experimental group students showed more critical thinking abilities in credibility of sources and observation than the second experimental group students. In addition, the statistical interactions of science learning outcomes with learning methods on argumentation and critical thinking abilities in general and in 3 subscales were not found to be significant. Nevertheless, there was a statistical interaction of the two variables on critical thinking abilities in credibility of sources and observation.
3	2016	Krissada Tongprapai, Sasithep Pitiporntapin, Krissana Shinnasin and Oraya Jamjai	8th	Development of grade 8 students' argumentation skill in nutrients and life unit using Socio-Scientific Issue (SSI)-based teaching	The argumentation skill of all students were in good level after learning with SSI-based teaching. In addition, the researchers found that 26 students (68.40%) increasingly developed their argumentation skills. When considering each component of argumentation, the best components that students developed were claim and warrant, and the component that few

No.	Year	Author	Grade	Title	Key result
					students developed were using evidence.
4	2018	Achara Singsorn, Pornthip Atichart and Jeerapan Suksringam	9th	Development of argumentation and analytical thinking of Mathayomsuksa 3 students with different science learning outcomes who learned socioscientific issues using mixed methods based on the adapted brain-based learning and the traditional learning approaches	The students as a whole and as classified according to science learning outcomes who learned the socioscientific issues using the mixed methods based on the adapted brain based-learning and the traditional learning approaches showed developments of argumentation and showed gains in analytical thinking abilities in general and in each aspect from before learning. There were statistical interactions of science learning outcomes with learning model only on analytical thinking abilities as a whole and in the subscale of analysis of relationship, in which the students with high science learning outcomes who learned the socioscientific issues using the mixed methods based on the adapted brain-based learning approach had more argumentation abilities and analytical thinking abilities than other group students, and evidenced more analytical thinking abilities as a whole and in each aspect than the counterpart students. However, the students with different science learning outcomes did not show different argumentation abilities.
5	2015	Phatcharapron Bunyathasanee Akarat Tanak and Teerasak Veerapaspong	10th	The development of argumentation skills on force and law of motion of grade 10 students using context-based learning	The results showed that 51.49 percentages of students had argumentation skills in level 4 and 5 during learning, after learning 95.59 percentages of students hold in these levels. In consideration of the average argumentation skills of students during learning with 4 lessons, there were 8.1 percentages of students showed the argumentation skills in level five, in which they could present complete elements of argumentation. However, the result from post-test revealed that all of students showed the claims and the warrant of the elements and students in the argumentation skill in level 5 increased into 45.59%.
6	2015	Jumpa Suebsuntorn, Pattamavadee Pasacha and Phuvadol Gomontean	10th	Comparisons of argumentation and critical thinking from learning socioscientific issues using the mixed methods based on the problem-based learning method and the 5E - learning cycle	The students as a whole and as classified according to understandings of the nature of science who learned the socioscientific issues using the mixed methods based on the problem-based learning method and the 5E learning cycle approach showed developments of argumentation from the 1st to 4th test; and showed gains in an entire critical thinking and in each of 4 subscales from before learning. The high science understanding students

No.	Year	Author	Grade	Title	Key result
				approach of Mathayomsuksa 4 students with different understandings of the nature of science	indicated only more critical thinking in 3 subscales except for the deduction subscale than the low science understanding students. The experimental group one students evidenced more argumentation and critical thinking abilities in general and in 2 subscales: induction and assumption identification than the experimental group two students. In addition, there were statistical interactions of understandings of the nature of science with learning method only on 2 subscales of critical thinking abilities: induction and assumption identification.
7	2015	Asawin Thanapud, Sasithep Pitiporntapin and Pattanee Jantrarotai	10th	Development of grade 10th students' argumentation skills in natural resources unit using socioscienctific issues-based teaching	Most of students developed their argumentation skills from 16.67 to 83.33%t. There was 75% in level of good to excellent. Moreover, they also developed in each component of argumentation: claim; warrant; evidence; counter argument; and supportive argument. The component that most students for developed was evidence for support warrant and the component that less students developed was supportive argument.
8	2016	Penphun Siripan, Pornthip Atichart and Jeerapan Suksringarm	10th	Comparisons of argumentation and critical thinking abilities after learning socioscientific issues using the mixed methods based on the problem-based learning method and the 7E-learning cycle approach of Mattayomsuksa 4 students with different genders	The student as a whole and as classified according to gender who learned the socioscientific issues using the mixed methods based on the problem-based learning method and the 7E-learning cycle approach showed developments of argumentation and showed critical thinking in general and in each subscale from before learning. The students with different genders did not differently indicate argumentation and critical thinking abilities in general and in each subscale after learning socioscientific issues. The students who learned the socioscientific issues using the mixed methods based on the 7E-learning cycle approach evidenced more argumentation and critical thinking abilities as a whole and in each subscale than the counterpart students. In addition, there were statistical interactions of gender with learning method on argumentation and critical thinking of the students.
9	2016	Keasorn Sukcharee and Nongnit Morakot	10th	Comparisons of argumentation and critical thinking from learning socioscientific issues using the mixed methods based on the	The students as a whole and as classified according to achievement motives showed developments of argumentation abilities from the 1st test to 4th test; and showed gains in critical thinking abilities in general and in each subscale from before learning. Also, the high achievement motive students

No.	Year	Author	Grade	Title	Key result
				Problem – based Learning Method and the 7E-Learning Cycle approach of Mathayomsuksa 4 students with different achievement motivations	indicated more argumentation and critical thinking in general and in each subscale than the low achievement motive students. The experimental group students indicated more argumentation and critical thinking in general and in each subscale than did the control group students. In addition, there were statistical interactions of achievement motive with learning method on argumentation and critical thinking in general.
10	2017	Wipa Arsingsamanan, Sureeporn Sawangmek and Maliwan Nakkuntod	10th	An action research for enhancing genetics conception of grade 10 students by learning management using scientific argumentation in socioscientific issues	The 4 steps of learning management by using scientific argumentation in SSI as follows: the first step is introduction to lesson study by using SSI. Teachers choose SSI which refers to scientific concept closing to students' lives at present and Learning Medias applied in teaching technique might be appropriate for SSI in both positive and negative. Secondly, teachers explore students' knowledge by using SSI; therefore, students might investigate various reliable resources in both positive and negative ways. Thirdly, teachers might discuss with students about SSI by providing them pieces of advice and asking them questions; thus, students enable to express their opinions and point-of-views. Finally, it is the conclusion step. Students might participate in discussion about SSI and summarize the concepts of its after completing the lesson, 2) the transcription is considered to be the most developing genetics concept among students. Moreover, students are able to completely understand biotechnology of the genetics concept as 85.42% and translation is considered to be the most misconception genetics concepts as 11.11%.
11	2017	Wilaiwan Songsil and Chatree Faikhamta	10th	Grade 10 students' scientific argumentation in socio-scientific issues	Students' scientific argumentation skills as a whole in every scenario were at the fair level. The findings also showed that most of the students have expressed their claims and arguments to support good claims but lacked the skills to find the evidence to support a credible reason, a counter arguments and supportive arguments.
12	2015	Nittaya Tipsrirach, Pattamawadee Pasacha and Bhuvadol Komontein	11th	Comparisons of effects of learning socio-scientific issues using the mixed methods based on the Problem-based	The student as a whole and as classified according to achievement motivation who learned the socioscientific issues using the mixed methods based on the problem-based learning method and the 5E-learning cycle approach showed

No.	Year	Author	Grade	Title	Key result
				Learning Method and the 5E-Learning Cycle Approach on argumentation and analytical thinking abilities of Mattayomsuksa 5 students with different understandings of the nature of science	developments of argumentation from the 1st -4th test: and showed analytical thinking abilities in general and in each subscale from before learning. The students with different understandings of the nature of science did not differently indicate argumentation and analytical thinking abilities in general and in each subscale after learning socioscientific issues. The students who learned the socioscientific issues using the mixed methods based on the problem-based learning method evidenced more only analytical thinking abilities in the subscale of analysis of organizational principles than the counterpart students. In addition, there were no statistical interactions of understanding of the nature of science with learning method on argumentation and analytical thinking abilities of the students.
13	2015	Thushaneeya Thongngoen, Poramate Chanpeng and Jeeraphan Suksringarm	12th	Comparison of effects on argumentation and logical thinking abilities when learning socioscientific issues using the mixed methods based on the scientific method vs the good science thinking moves on Pratomsuksa 6 students	Students overall, and the students as classified in the two groups, showed developments of argumentation abilities from the 1st test to the 4th test, and showed gains in logical thinking abilities in general in each of 2 sub-scales from before learning began. High science aptitude students evidenced more argumentation and logical thinking abilities as a whole and in 2 sub-scales than their counterpart students. Whereas the control group and experimental group of students did not show different argumentation abilities and logical thinking abilities as a whole and in 2 sub-scales. In addition, the statistical interactions of science learning outcome with learning model were not found to be significant.
14	2017	Saranyu Playrin, Jeeraphan Suksringarm and Mayuree Parakarn	12th	Comparisons of effects of learning socioscientific issues using the mixed methods based on the Lin and Mintzes Method and the 5-E Learning Cycle Approach on argumentation and analytical thinking of Matthayomsuksa 6 students with different achievement motives	The students as a whole and as classified according to achievement motives who learned the socioscientific issues using the mixed methods based on the Lin and Mintzes method and the 5-E learning cycle approach showed developments of argumentation abilities from the 1st test to the 4th test; and showed gains in analytical thinking in general and in each subscale from before learning. Also, the high achievement motive students indicated more analytical thinking in all and in each subscale than the low achievement motive students. Whereas two groups of the students did not show different argumentation abilities and analytical thinking

No.	Year	Author	Grade	Title	Key result
					abilities as a whole and in 3 subscales. Otherwise, there were no statistical interactions of the two independent variables on argumentation and analytical thinking in our all and in each subscale.

From Table 2, there are five studies related to the development of students' scientific argumentation through several methods. Most of the teaching method employed is Socio-Scientific Issue (SSI) (n=3), Context-Based Learning (n=1), and Adapted Brain-Based Learning and the Traditional Learning Approaches (n=1). Remarkably, there is one study using the Scientific Argumentation in Socioscientific Issues to promote students' conceptual understanding about Genetics (n=1).

There are eight studies aimed to study the effect of mixed teaching methods on students' scientific argumentation depending on several variables. The teaching methods that were mixed were: Problem-Based Learning (PBL) and 5E Learning Cycle approach (n=2), PBL and 7E Learning Cycle approach (n=2), Lin and Mintzes method and 5E Learning Cycle approach (n=2), scientific method and traditional learning method (n=1), and the scientific method and the Good Science Thinking (n=1). The variables that these studies tried to examine their effect while the students learned with those mixed teaching methods were: Academic Achievement (n=3), Understanding of the Nature of Science (n=2), Science Learning Outcomes (n=1), Science Aptitude (n=1). Interestingly, from the review of studies related to students' scientific argumentation, there is no study aims to explore the patterns of students' scientific argumentation. Consequently, the finding from this study can fulfil this gap of the literature in the science education context of Thailand.

Students' scientific argumentation pattern in science classroom in Thailand

The researchers observed the teaching and learning in Basics in Electricity in one grade 10 science classroom. The participating teacher employs the 5E-Learning Cycle Approach in teaching. The students' scientific argumentation in the Exploration and Explanation phases of the 5E-Learning Cycle Approach can be described as follows.

In the Exploration phase, the grade 10 students expressed their creativity and scientific argumentation in designing the new simple machine the following quotations.

Group 1: Automatic coin separation and counting machine

G1S1: What will we do?

G1S2: Automatic Coin Separation and Counting Machine? I see on YouTube (Ground, Warrant)

G1S3: Good! It helps to save time from separating coins. (Blacking S2)

G1S4: It's good idea! I'll sell it to a convenient shopping store. I have friends who their mom and dad run the grocery stores. I've heard after closing the store they have to separate and counting coins that took long time. (Ground, Warrant, Blacking S2)

G1S2: So, we chose to build an Automatic Coin Separation and Counting. It's real story we face at the grocery store. (Qualifiers)

Group 2: Mini vacuum cleaners from plastic bottles

G2S1: What will we create?

G2S2: We can make a pen pouch made from plastic bottles of water. (Ground, Warrant)

G2S3: No! No! We should create a simple machine, but the pen pouch is not a simple machine. (Rebuttals S2)

G2S4: We have to do something new and practical. (Warrant S3)

G2S3: Can we make a mini vacuum cleaner from plastic bottles? (Ground)

G2S1: Ok. I agree with you. (Qualifiers)

G2S2: So, we should plan together and go to buy equipment.

Group 3: Automatic whiteboard eraser

G3S1: What will we create (simple machine) to be good and useful?
G3S2: I want to make an automatic pencil sharpener. (Ground, Warrant)
G3S1: No, I disagree. It there anything else?
G3S3: Or we create an automatically whiteboard eraser? Because it is a problem that we encounter in the classroom. Whenever I delete a whiteboard, I frequently have to jump to erase the whiteboard. (Rebuttals S2, Claim, Warrant)
G3S4: It's a very good idea! (Qualifiers)
G3S2: I agree with you too. The budget is also not expensive. (Claim, Warrant)
G3S3: So, let's prepare the equipment. What things we should find to make the automatically whiteboard eraser? (Qualifiers)
G3S1: Ok. When we knew what equipment should be used, we separated to find them.
All: Ok.

Group 4: Mosquito trap

S1: What will we do to make an invention?
S2: A mosquito trap? At my home, there is lots of mosquitoes. (Ground, Warrant)
S3: Very good. My home too. (Claim, Warrant)
S4: So, we will create the mosquito trap, right? (Qualifiers)
S2: We should search for data from the internet first, in case that it is too difficult to make. (Blacking)
S3: Ok. I agree. (Warrant)

From the analysis of student-student discourse, the students in each group generated different patterns of scientific argumentation consisting of: Ground (Evidence), Claim, Warrant, Rebuttals (Counter argument), Blacking (Supportive argument) and Qualifiers. The students in Group 1 generated the scientific argumentation as: Ground and Warrant, Blacking S2, Ground, Warrant, Blacking S2 and Qualifiers. However, they did not provide the statement related to Rebuttals. The students in Group 2 provided the scientific argumentation as: Ground and Warrant, and Rebuttals and Qualifiers. They did not state about the Claim. The students in Group 3 generated the scientific argumentation as: Ground and Warrant, and Rebuttals and Qualifiers. They did not state about the Claim. The students in Group 4 provided the scientific argumentation as: Ground and Warrant, Claim, Warrant, and Blacking and Qualifiers. However, they did not provide the statement related to Rebuttals.

In the Explanation phase, the grade 10 students presented their innovative ideas in designing the simple machines in front of the class. There were some patterns of scientific argumentation as the following quotations.

Group 1: Automatic coin separation and counting machine

Group 1 presented the automatic coin separation and counting machine by using the video clip. Group 1 students presented that at the first time they made the wrong prototype that was not matched with their plan. The motor they used was too quick, so the machine was shake and the coins were not dropped into the appropriate hole. The size of holes must be fit with the size of coins i.e. a one-baht coin, a five-bath coin and a ten-baht coin. In making this machine, the students asked their parents to help them.

G2S1: Please show how the machine separate the coins again.
G3S2: Can it separate a two-baht coin?
Group 1: It cannot be used with the two-baht coin. (Claim)
G3S2: This machine uses electricity or battery?
Group 1: Battery.
Teacher: Why the machine has three legs (ranges)?
Group 1: Because we want the coins to move through the holes to the legs. (Warrant)
Teacher: I notice that there is one part attached with the legs. It is the same as the legs or it is a joint?
Group 1: It is a joint because if it is the same part with the legs it will be shake. (Warrant)
Teacher: Why you have to arrange the holes like this?
Group 1: Because it has to range from smallest to biggest. (Warrant)
Teacher: How much does it cost?
Group 1: 170 Baht. (Warrant)

Teacher: What is the different when using the small and big motors?
Group 1: If we use the big motor the machine will be shake a lot. If we use the small one the machine will not shake. From our experiment, the 5V motor is OK. We faced several problems while doing this machine. Sometime, the machine is shake and bounced from the floor. We have to add friction in the range by using glue. (Warrant)

Group 2: Mini vacuum cleaners from plastic bottles
G1S1: How can the vacuum cleaner work?
Group 2: The sound of this vacuum cleaner is quite loud like the mosquito trap. (Claim)
G1S3: Is the mosquito dead?
Group 2: No. It is not the mosquito trap. (Warrant)
G2S2: How can you make the machine sucks the dirt? What is the principle of it?
Group 2: It uses the principle of physics of machine. (Warrant)
G2S1: Why the machine cannot suck the dirt?
Group 2: I think it may be because a battery. So, the propeller did not rotate and the machine cannot suck the dirt. (Warrant)
Group 2: I think we should study from the internet more. I guess it is not related to the battery. (Blacking)
Group 2: Umm. I think the battery is not involved. It is the motor. (Qualifiers)
Group 2: I think our focus is wrong. (Warrant)
Group 2: So, we should use the motor from an electric fan. It is big and has more power. If we have more power, the machine will be able to suck dirt better. (Claim, Warrant)

Group 3: Automatic whiteboard eraser
Group 3 students presented the automatic whiteboard eraser in front of the classroom. The Group 3 students stated that they searched the information from the internet. The other people normally use the towel. So, they changed the material. The first prototype had one wheel and it is tilted, so they changed to two-wheel. The Group 3 students stated that they had too little time, so the automatic whiteboard eraser was not good as they expected.

Group 4: Mosquito trap
Group 4 students presented about the mosquito trap they created. The weaknesses of the created machine were the electric cable was easily broken and the equipment was not strong enough. After tried out they learned that the mosquito like the sweat smell from socks.
G1S1: When the machine can trap the mosquito, how will you deal with it?
Group 4: We did not think yet.
S2: Why you choose to use the black socks?
Group 4: From our experience, because the mosquito like black color. (Ground)
G2S3: What is the maximum range for this mosquito trap?
Group 4: About 2 meters in the open area. (Claim, Warrant)
Group 4: We cannot answer from our experience because each individual has the different experience. (Rebuttals)
Group 4: Yes, I agree. We should search from the internet. (Warrant)
Group 4: I used to face the problem from my friend. He used a lot of anti-mosquito spray and he was nausea. So, we should study the anti-mosquito spray is dangerous or not. (Ground, Warrant)
Group 4: We should spray it in the room and leave it least 10 minutes before turning on the air-conditioning. (Warrant)
S3: The anti-mosquito liquid has both dangerous and no dangerous?
Group 4: Some are dangerous, but some are not because it has only some unique smell that the mosquito does not like. (Warrant)
Group 4: Some are easy-vaporing liquid. (Warrant)
Group 4: Some are liquid. (Warrant)
Group 4: I saw some people left it at night because there are lots of mosquito at night. (Ground, Warrant)

From the analysis of student-student discourse in the Explanation phase, the students in each group generated different patterns of scientific argumentation consisting of: Ground (Evidence), Claim, Warrant, Rebuttals (Counter argument), Blacking (Supportive argument) and Qualifiers. The students in Group 1 generated the scientific argumentation as: Claim and Warrant. However, in the statements there was no Ground, Rebuttals,

Blacking and Qualifiers. The students in Group 2 provided the scientific argumentation as: Warrant, Claim and Qualifiers, Ground and Rebuttals. However, they did not mention about Claim and Blacking. The students in Group 4 provided the scientific argumentation as: Ground, Rebuttals and Warrant. However, they did not provide the scientific argumentation related to Claim, Rebuttals, Blacking and Qualifiers.

This study revealed that the grade 10 students in the science classroom in the Thai context face the problem in generating a scientific argumentation. This problem is arisen because science students in Thailand are not thoroughly promoted to attain a scientific argumentative skill. The shift from a teacher-centered approach to a student-centered approach in the current wave of national educational reform in Thailand does not yet yield the effect on the students' ability to argue with others. Students tend to keep quite in a science classroom rather than seeking for evidence to support their claims and generate their warrants. In the Thai culture, saying something wrong is a shame and showing that a speaker is fool or has little knowledge on the topic. So, the best choice for this situation is keeping quiet and letting the situation (e.g. someone asking question, discussion, debate, etc.) pass. To be noticed in the classroom environment in Thailand, students normally keep quite while a teacher asks like "Do you have any question (to ask me or your friend)?" or "Do you have any thin to debate or discuss on this topic?" So that, in the Thai context, we can say that the educational norm does not promote students to practice making argument and/or argue back to others' arguments (Counter Argument) (Toulmin, 2003). Also, the environment of student-student argumentation in the science classroom in the Thai context is not enough promoted. This is the reason why the grade 10 students in this study face the problem about generating all patterns of scientific argumentation including Ground (Evidence), Claim, Warrant, Rebuttals (Counter argument), Blacking (Supportive argument) and Qualifiers (Toulmin, 2003).

In addition, the argumentation between students and a teacher in the Thai context is so limited. In the Thai culture, Thais believe in seniority; the junior must show his or her respect to the senior. In the science classroom, the science students must keep their respect to their teacher; though their teacher is right or wrong. The belief of seniority is one cause in the Thai context that may impede the development of a student-teacher argumentative skill. This study urges the urgent need to cultivate the scientific argumentation culture in science teaching and learning in Thailand. Some culture that impedes the development of students' scientific argumentation must be justified. For example, the students should be informed that arguing with senior is not bad thing if it is conducted with good mind and good reason through a respectful manner. Asking questions back or argue back to others in a science classroom is not bad thing it helps to further develop fruitful knowledge for yourself and others. This process is difficult and may take time, but it should be truly started right now.

Songsil, Pongsophon, Boonsoong, and Clarke (2019) noted that students' gender, content knowledge, and reasoning ability did not emerge as significant factors influencing the development of their scientific argumentation skills after being exposed to the revised Argument-Driven Inquiry (rADI) model. This study raises an intriguing research question for future exploration: whether students' cultural factors and norms influence the development of their scientific argumentation skills. Additionally, the teaching and learning environment within the science classroom emerges as a potential factor that could, to some extent, impact students' proficiency in scientific argumentation.

Implementation

This research urges for more quality argumentation between students and students as well as students and their teacher in science classrooms in education context of Thailand.

Science teachers should create safer classroom atmosphere for students to deliver their argumentation. Some particular norms and values in traditional Thai society should be adjusted (e.g. seniority, social status, etc.) to suit and encourage more quality scientific argumentation from students. This process cannot be finished in one day; however, it needs time to cultivate and grow in science classroom contexts. In addition, school administrators should understand and facilitate their teachers in their efforts for improving scientific argumentation in their classrooms. A science classroom with quality argumentation is generally not quite as a traditional classroom. Without understanding and supports from school administrators, the success of developing quality scientific argumentation in classrooms in Thai context is very hard to reach. In addition, this study suggests that additional research should be done to pave the ways for cultivating a culture of scientific discussion and argumentation in science classrooms in Thailand.

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