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Integrating Argument-based Science Inquiry with Argument Mapping in Physics Learning: A Literature Study

Moh. Nurudin

Department of Physics Education, School of Postgraduate Studies
Indonesia University of Education, Bandung, Indonesia

Corresponding author: mn.elfaqih@yahoo.com

Abstract. The purpose of this study is to develop quality of physics learning at high school in order to become more effective in improving students' skills based on 21st Century Skills Framework. This paper discussed how argument-based science inquiry (ABSI) developed from scientific writing heuristic (SWH) learning model. Both ABSI nor SWH is a learning model that train and improve students' argumentation skills. In the other side, argument mapping is proven successfully to promote critical thinking skills. Additionally, known that argumentation is a part of critical thinking skill. This study can be used for learning model choosing that aimed to promote students' argumentation and critical thinking skill. The result of the study is that it is very possible for teachers to use argument mapping in ABSI to promote students critical thinking skill. In the other side, the use of argument mapping in ABSI hoped can increase effect ABSI to promote argumentation skill. A literature study is used in this study as a preliminary study. In the future, an experimental study can be done to prove the effectiveness of using argument mapping in ABSI in physics learning.

INTRODUCTION

21st century can be identified by a rapid development of many kinds of technology especially about information and communication technology. It supports an opened information access. In one side, this thing has positive impact to make knowledge improvement easier because any kind of needed information can be accessed so easily. But in other side, a mistake in selecting an information will have a very negative impact that can cause a misunderstanding about many things. Because of that, 21st century learning is not just about knowledge transfer oriented any more. Knowledge transfer from teacher to students now can be substituted by internet and other kind of information and communication technology. Almost any kinds of information can be found in the internet so many kinds of information about lesson materials can be accessed by student. In this case, teacher is just a learning facilitator.

Because of these reasons, orientation about learning has changed. From knowledge transfer from teacher to student to higher order thinking skills training. Based on [1], learning must be oriented in improvement innovation skills. They include creativity and innovation, critical thinking and problem solving, and communication and collaboration. This concept named by 4C's. Argumentation skill supports communication activity more effective. Critical thinking help students select valid information in this opened information access era. Finally, learning must be innovated in order to train and develop students' high order thinking skills. One of them, argument-based science inquiry hoped can fulfill these expectations.

THE NATURE OF ARGUMENTATION

Scientific argumentation skill is a part of scientific reasoning that can be fostered through lab activity [2]. In this activity, students analyze correlations evidences that found in lab and kind of explanation needed to explain these evidences. The progression that indicates emphasized scientific argumentation is where students (1) investigate questions and assumptions from a puzzling phenomenon or event, (2) use the data from a self-designed investigation to make a claim and justify and defend the claim with supporting evidence, and (3)

provide a scientific explanation based on the findings. Figure 1 shows diagram of scientific argumentation that built form inquiry activities. Based on that illustration, claim is built from observation followed by explanation based on supporting evidences.

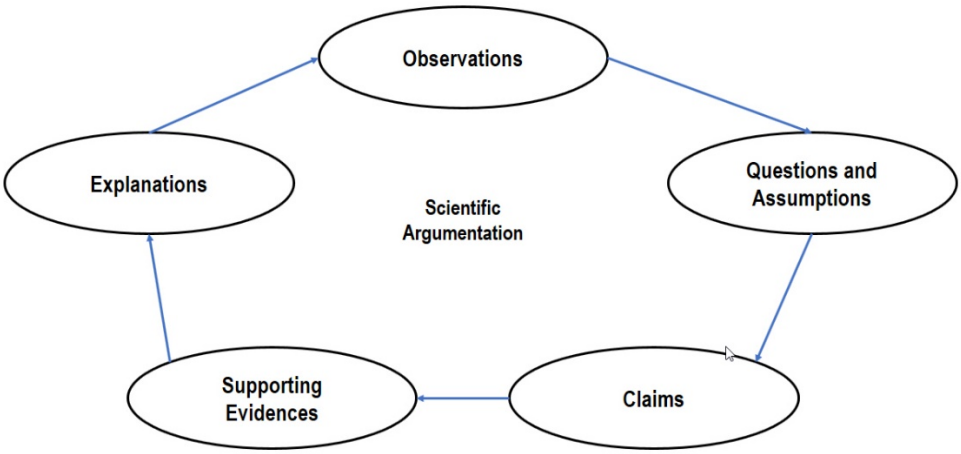

FIGURE 1. Scientific Argumentation Cycle [2]

Arguments include premises (statements of fact), co-premises, alternative premises (objections), and conclusions (decisions) [3]. The premises and conclusions are written as declarative statements in full sentences. Based on its complexity, there is two kinds of argument, simple argument and complex argument. A simple argument has one or more premises and one or more conclusions. Complex arguments have one or more overlapping premises or conclusions.

The first most representative argumentation is declared by Toulmin [4] known as Toulmin Argumentation Pattern (TAP). It was one of the first to challenge the ‘‘truth’’-seeking role of argument and to consider, instead, the rhetorical elements of argumentation and their function [5]. Based on TAP, argumentation consist of data, claim, warrant, backing and rebuttal [4, 6]. Figure 2 shows how components of TAP is correlating each other. Claim is base of an argument that must be supported valid data. To explain how data correlate to claim and support it, warrant must be made. Backing is additional supporting evidence that strengthen warrant. Claim that opposites claim is called rebuttal.

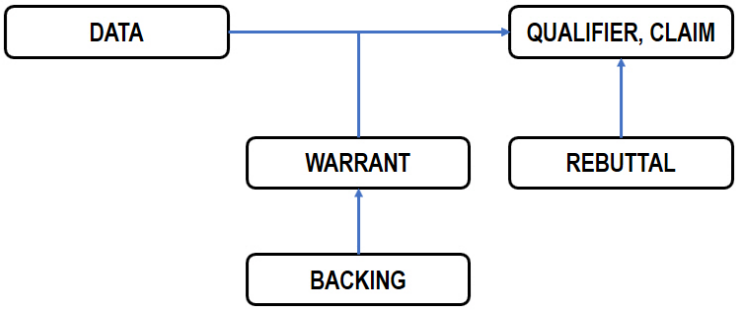

FIGURE 2. Structure of Toulmin’s Argument Pattern (TAP)

ARGUMENT-BASED SCIENCE INQUIRY (ABSI)

Inquiry-based instruction is one of the most popular in science teaching. It is proven can improve students’ science process skills because it consists some of hands-on activities. But it is supposed not enough. Student should can explain what they elicit from inquiry investigation. In other term, they must make an argument that can explain data they elicit form inquiry investigation [2]. Based on these facts, many of education experts did studies that blend inquiry and argumentation.

There are some instructional approaches that integrate inquiry and argumentation in science teaching e.g. argument-driven inquiry, personally seeded discussion, and Science Writing Heuristic (SWH) [7]. Argument-based Inquiry (ABI) use SWH as its base. If it is applied in science teaching it can be called Argument-based Science Inquiry (ABSI). SWH or ABSI is developed to integrate argument-based activities, collaborative group work, and writing to learn strategies. SWH proposes two flexible templates to guide teachers and students

shown in Table1. From that table, we can see that ABSI is started by inquiry activities including Pre-Instructional Activities and Participation. Then, based on findings of that inquiry activities, students build an argument by group work. It started by negotiation phase I, II, III, and IV and closed by exploration that explain how their conception has changed during learning process.

TABLE 1. SWH Template for Teacher and Student

Teacher template	Student template
Pre-instructional activities such as exploration of students' prior understandings, brainstorming and questioning.	What are my questions?
Participation in activities	What did I do?
Negotiation phase I – writing personal meanings for Investigations	What can I claim?
Negotiation phase II – sharing and comparing data understandings with peers	Why am I making these claims?
Negotiation phase III – comparing science ideas to textbooks or other resources	How do my ideas compared with others?
Negotiation phase IV – individual reflection and writing	
Exploration of post-instructional understandings	How my ideas changed?

ARGUMENT MAPPING

An argument map is a graphical representation of the logical structure of an argument – the ways in which premises, intermediate steps and the final conclusion all fit together [8]. Unlike mind mapping and concept mapping, argument mapping is interested in the inferential basis for a claim being defended and not the causal or other associative relationships between the main claim and other claims [9].

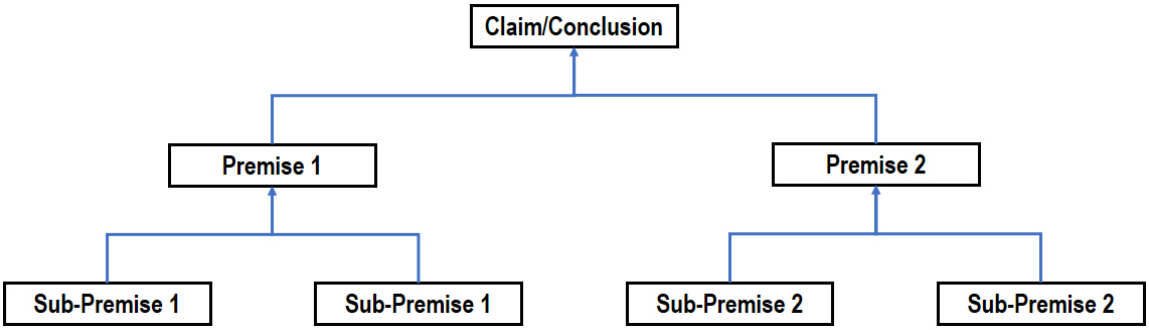

FIGURE 3. Structure of Argument Mapping

In one side, concept and mind mapping draw concepts and show relationships to facilitate or demonstrate their own understanding of complex concepts. In the other side, argument mapping is used to develop clarity of reasoning based on supporting evidence, and to come to a conclusion (Billing & Kowalski, 2008). Other difference between argument mapping and the others is that argument mapping is built form bottom to up. It means that claim/conclusion is lied at top but written last. First, we have to draw premises from bottom and finally finished by claim/conclusion that written in the top. Claim is built based on the premises that drawn early from bottom. Figure 3 shows how an argument mapping is built and Figure 4 is example of an argument mapping about hydrostatic pressure in physics teaching.

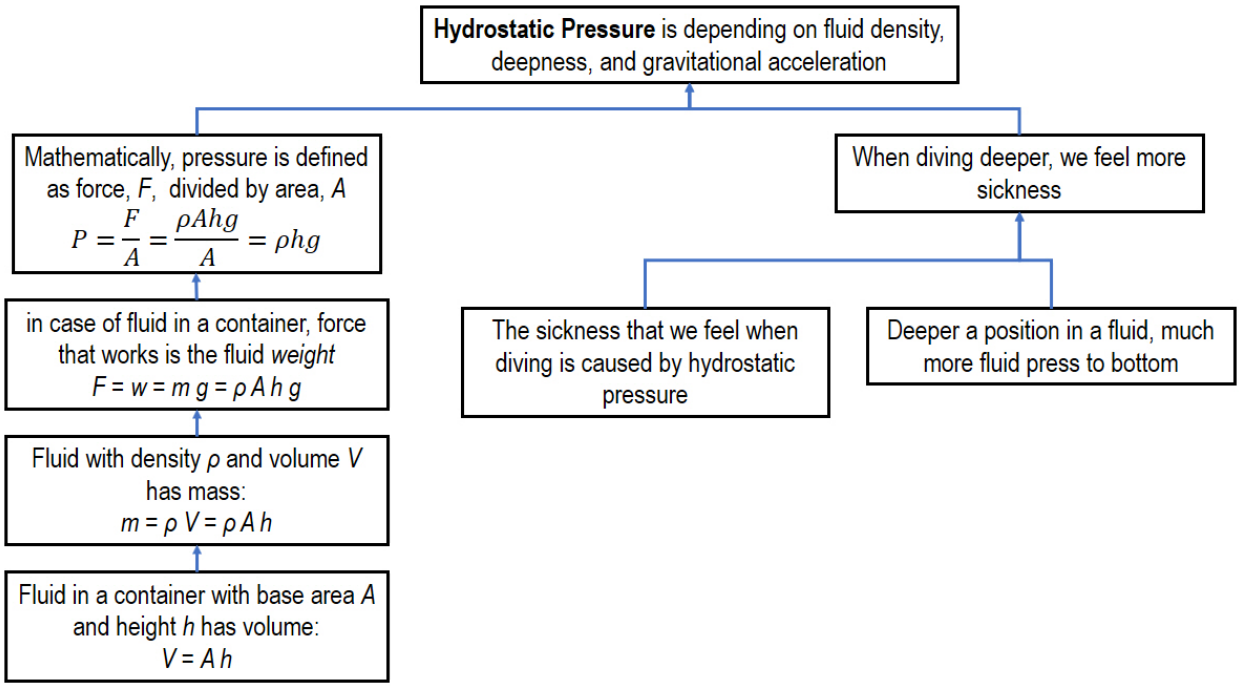

FIGURE 4. Example of Argument Mapping in Physics

TABLE 2. Argument-based Science Inquiry with Argument Mapping Activities for Teacher and Student

Phases of Activities	Teacher Activities	Student Activities
Pre-Laboratory Activities	Exploring of students' prior understandings, brainstorming and questioning.	Identifying problem Planning and designing observation or experiment
Participation	Giving motivation to student to get involved in lab activity	Doing observation or experiment that planned and designed before
Negotiation I + Argument Mapping	Guiding students to think about the meaning of their data that elicited from lab activity through argument mapping	Making an argument mapping based on argumentation elements to make a conclusion about their finding from lab activity
Negotiation II	Teacher encourages students to negotiate their understandings of the data with their peers	Discussing with their peers about the finding of lab activity to compare their understanding to the others'
Negotiation III	Setting aside addition information (printed out of any article, internet access, etc.)	Comparing their claim/understanding to addition information that teacher prepared.
Negotiation IV	Encouraging and guiding students to make a complete report	Making a complete report that includes lab activity and result of discussion and reading addition information
Exploration	Encouraging students to make a reflection and setting aside the form	Making a reflection that explain how their conception are changed during learning

DISCUSSION

As we discussed before, argument-based science inquiry (ABSI) is developed from science writing heuristic (SWH) so the phases of activities of both teacher and student is identic. Argument mapping as a tool that help someone organize an argument, can be integrated in ABSI. The most possible activity that can integrate with argument mapping is when student make a claim or explanation of lab activity finding. That activity is included in Negotiation I phase.

In ABSI itself, student analyze data that elicited from lab activity and make preliminary conclusion. The conclusion is made in verbal from. Everything that they get form data analyzing are written in narrative form. To strengthen effect ABSI in argumentation skill that trained in ABSI, argument mapping is assumed can do it. The conclusion is not written in narrative form any more. Student is encouraged to transform their understanding from lab activity in mapping form. Table 2 shows activities of both teacher and student in ABSI that integrated with argument mapping (ABSI-AM). Argument mapping is also proven can enhance students' critical thinking skills [10]. It is caused that one of critical thinking elements is recognize argument [11]. So, we can expect that integrating argument mapping with ABSI can improve students' argumentation and critical thinking skills all at once.

CONCLUSION

In many study, using argument mapping is proven can improve critical thinking skills [8, 12, 13, 10]. In other side, applying ABSI in learning can improve argumentation skills [14, 15, 7]. Additionally, argumentation is part of critical thinking skill [11, 16]. So, we can make a main conclusion that using argumentation can improve argumentation and critical thinking skills. This is a preliminary study. Hence both of argumentation and critical thinking skill is one of the most important skills that everyone must have, in the future a study can be done to study effect of using argument mapping in argument-based science inquiry to improvement of argumentation and critical thinking skills.

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