Implementation of Science Writing Heuristic Approach to Develop Chemistry Students' Argumentation Skill

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Abstract—**The important challenge in science education is improving students' scientific literacy, including argumentation skill. Argumentation skill was crucial to address the problem related to scientific issues that occurs in every aspect of lives. The Science Writing Heuristic (SWH) approach has been used successfully created an environment that forces students to construct their knowledge through argumentation process. The purpose of this current study was to implement the SWH approach to develop chemistry students' argumentation skill in general chemistry laboratory class. The research was carried out using a quasi-experimental design with treatment and control groups. The participants involved in were first-year general chemistry laboratory students. The students in the experiment class were required to construct argument using writing as tool for scientific investigation process. In contrast, another group student in the control class performed and wrote up their labs using traditional setting (teacher-directed approach). An open-ended test was used for evaluating the student's argumentative skills. The assessment scores of the students of both classes were compared. The results show that students who received the laboratory instruction approach scored lower than those students in the experimental class on various aspect of argumentation, suggesting the SWH-based laboratory instruction is valuable in promoting students' argumentation skill. It was observed in the experimental class that high-ability students performed better than low-ability students at generating complete arguments, indicating the success in learning argumentation skills was related also to student ability level instead of instruction of argumentation skills. This study suggests that choose the proper strategy in teaching process contribute in fostering students to develop the argumentation skills.**

Keywords: inquiry strategy, student-centered, science writing heuristic, argumentation skill

I. INTRODUCTION

A significant challenge for science educators is how to create meaningful opportunities for students from thinking about science as a collection of facts to be memorized toward a deeper understanding of concepts and scientific ways of thinking [1]. Traditional laboratory with cooked-book style activities found to be failure to promote students in the discussion and analysis of central ideas, and valued science practices [2]. Many studies have suggested the use of active language and an inquiry-based teaching method in engaging students' inquiry activities [3, 4]. Students need to be active in discovering new ideas and critiquing claims in order to know how scientist works [5]. The more opportunities students are given to immerse in this argumentative inquiry process, the more likely they are able to think scientifically [6].

Therefore, transformation from recipe style experiment to a set of experiments that engaged students' argumentation skill is negligible. Particularly, argument is viewed as a critical element of science instruction to enhance scientific literacy. Argumentation will facilitate students to construct conceptual understanding [7]. Current studies reveal that engagement in argumentation process develops students' conceptual understanding, reasoning abilities and cognitive, meta-cognitive, communication, and critical thinking skills, which further cultivates scientific literacy [7]. The process for engaging students' argumentation skill require students to make claims, select proper data to support their claims, and justify claims with scientific evidence. During this scientific argumentation, they will reflect their own ideas and learn about ideas of others.

One of the method for promoting students scientific literacy, including argumentation is Science Writing Heuristic (SWH) approach, the writing-to-learn strategy. The SWH is an inquiry-based approach which grounded within the constructivist philosophy. This approach was developed by Hand and Keys in 1999 for use in the laboratory. The writing process provides students structured format to make connection between laboratory activities and for thinking about and writing up their laboratory report [8, 9]. Here, the activity of students in writing up the laboratory report show students' argumentation skills which is expressed in a scientific report. The SWH report format differ to traditional format, since it replaces the section of purpose, method, observations, results, and conclusion with provokes eliciting questions, knowledge claims, write the evidence, observable data, and reflection [8, 10] (Table 1). In addition this approach also requires both

students and teacher to take an active role in the laboratory process compared to the traditional cookbook laboratory approach.

As can be seen in the Table 1, the SWH approach provides opportunity for students to develop their own questions that they will answer by conducting an experiments. This activity provide "connection" between previous knowledge with the context of experiment. The questions formulated to be answered by conducting an experiments. As students develop their question, students will think critically on the given issues to decide what the appropriate problems to be answered. The next part of the SWH approach is designing an experiment according to their own questions. This section aims to facilitate a student to develop the students' science process skill in designing an experiment. In addition, this section also provides the space for students to understand the basic principal of the activity. This step guides students to use induction, analysis, evaluation, and explanation skills in construction a "mini research procedure".

TABLE I. COMPARISON OF THE TRADITIONAL AND SWH LABORATORY REPORT FORMAT

Report component	Traditional report format	SWH report format
Title	Provides by teacher	Provides by teacher
Aims	Provides by teacher	Students formulate the proper question related to the relevant theoretical background of the experiments
Outline procedure	Teacher provide step-by-step procedure	Students design their experiment to answer their own questions
Observations	Students follow the outlined procedure in the laboratory manual	Students conducted their own outlined procedure
Data, balanced, equation, calculation	Lab partners check with one another to be certain that both have all the experimental data and then leave after completion of data and observations.	Students talk with their other group members and with other groups to compare and discuss their findings.
Claim	No claim made by students	Students write and discuss an appropriate claim
Evidence	No evidence was written specifically by students	After completing the observation data, students begins to look for the trend, evaluate, and provide supporting evidence for they claim.
Discussion and analysis	Students may ask questions of their partners or of the instructor and then leave the laboratory.	Students work together to negotiate the meaning, construct a concept, and answer the begining questions.
Reflection	No reflection	A short discussion of topics for reflection on the overall experimental Investigation, errors, and applications may also occur.

The next section is the observation. Here, students describe what they observed or learned. Students discuss their observations and/or knowledge gained with other students. The goal is to experience students to argue and using science language. After then, students are asked to make a claim. This requires critical thinking in order to link what they did, what they observed, and their data or answers to questions with a strong statement that can be supported with evidence. Students then read an article, text, or other source that relates the topic to the real-world or further explains the topic. Students are asked to read for understanding and then asked to write and discuss how the article related to the topic. Carrying out these activities in a collaborative environment forces students to confront and reflect on their own thinking. The final stage of the SWH approach asks students to reflect on how all of the sections related to what they are currently doing in class, whether or not their previous ideas have changed, and/or what they learned from [11].

Here, this research aims to develop students' argumentation skill through the implementation of the SWH approach in General Chemistry laboratory course. The results will provide an information of the alternative valuable approach to promote students' argumentation skill in chemistry laboratory.

II. METHODOLOGY

A. Participants and Research Design

This study employed a quasi-experimental design with treatment and control groups. The participants of this study were sixty-one freshman students majoring in Chemistry Program who enrolled in General Chemistry Laboratory course. Thirty students from one laboratory section were assigned to the treatment group using the SWH approach and thirty-one students from the other laboratory section were assigned to the control group using the traditional general chemistry laboratory teaching approach. The students in both treatment and control groups were assigned to work in groups of two to three. At the beginning of the class, students in the treatment (experimental) group were introduced to the SWH approach. The students are provided with the template of SWH as follows:1. Generating questions; 2. Preparing procedure to answer the questions; 3. Doing proper observation for collecting data; 4. Making claim according to the proposed questions; 5. Explain the evidence to support the claim; 6. Reading relevant references for supporting the claim; and 7. Reflection. Students in the treatment class were encouraged to be involved actively in discussion related to the context related to the activity as an initiating to do SWH activities. On the other hand, students in the control group were conduct activities using traditional approach. Here, the students were provided the detail instructions regarding the purposes of the experiment, theoretical background, and the procedure. The students in the control group used ordinary lab report as follows: 1. Experiment purpose(s), 2. Procedure, 3. Observation, 4. Conclusion, 5. Discussion.

B. Data Collection

Data were collected using assay writing test which were given to both the treatment and control groups. The test scores were examined as pre-test and post-test for measuring the argumentation skills for both groups of students. The test consists of eight open-ended questions related to the indicator of argumentation skills according to the Toulmin's model argumentation (claims, warrant, evidence, and counterclaims) [12]. The instrument was validated by two experts and was implemented after the revision made. Descriptive statistic and normalization gain (N-gain) were used to analyse the data. The ability of student in the experimental class to generate written arguments was evaluated from their student report.

III. DISCUSSION

A. Student' Argumentation Skills

Students' skills in arguing are measured by evaluating four main aspects namely the ability to declare claims, delivered the reason for making claims (warrant), serving evidence, including numerical, descriptive data, concrete examples or fact to support the claim being stated (evidence), and explaining alternative assertion (counterclaims). The descriptive statistic revealed that students' argumentation in both classes was not generally good before the instruction. Yet, the ability of each argumentation skills demonstrated better-developed after the instruction. However, the skills in argument involving claims, warrants, evidence, and counterclaims of the students in the experimental group found higher compared than those students who did experiment using traditional approach (Figure 1). Students were requested to provide accurate evidence for supporting their claims or even to struggle with supportive evidence and reference when doing counter claims.

The results show that both strategies (traditional and SWH approach) facilitate the development of students' argumentation skills. However, implementing SWH approach which are focusing more on argumentation skills and providing wide opportunities to students for practicing those skills substantially better-developed the students' skills in making arguments (Figure 2).
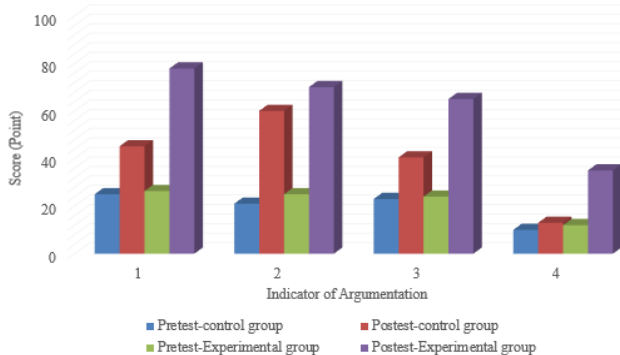

Fig. 1. Students' ability in arguing in the control and experimental group. 1. Making claims, 2. Warrant, 3. Evidence, and 4. Counterclaims.

It can be seen that students in both classes could develop an ability to make claims and warrant after the instruction, but still the control group low scorer compared to the experiment group.
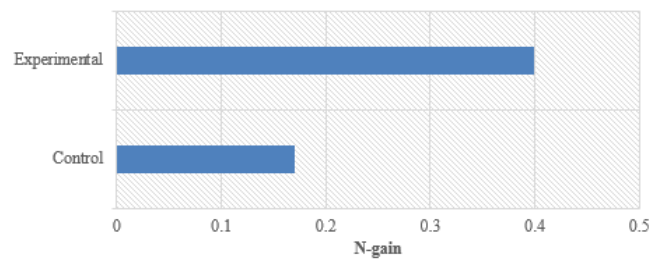

Fig. 2. The general changes in argumentation performance. Control: students did experiment using traditional approach. Experimental: Students conducted experiment using SWH approach.

The results of the current study concurred the previous findings. Previous studies have shown that syntax provided in the SWH approach is success in assisting students to develop reasonable arguments in organic chemistry laboratory experiments [13], and the steps provided in the SWH approach helped students to create well-constructed arguments [14,15]. The result also revealed that more than half students in the experimental group could not generate well counterarguments, and very few students mastered these skill aspects in the control group. Counterclaims skill requires high order thinking skills which is more difficult cognitive task for students.

It was shown in Fig 3 that students with high and low academic achievement levels develop their argumentation skills after the implementation of SWH approach. Interestingly, the development of counterclaims was still scoring lower in both level academic students.
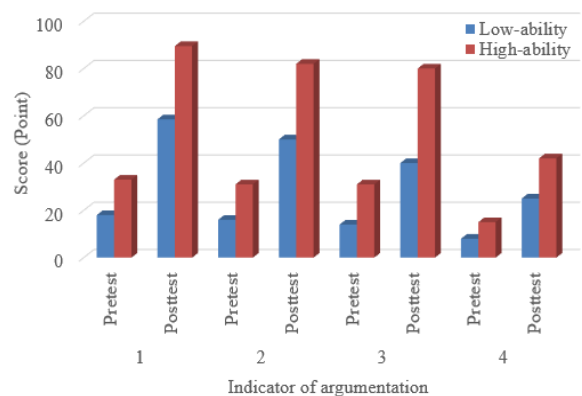

Fig. 3. Students' ability in arguing on each students' academic level in the experimental group. 1. Making claims, 2. Warrant, 3. Evidence, and 4. Counterclaims.

These results suggest that conceptual knowledge also contribute students' ability to master skills in constructing arguments. In addition, the high achievers found to learn more to make appropriate arguments. Taken together, this current research shows that students who participating in inquiry-based

investigation using SWH approach were capable of constructing arguments.

B. Student' Skill in Generating Writing Argument

The SWH template was design to facilitate the development of students' argumentation (Table 1). Students' skill in generating written argument was assessed by their experimental report. As can be seen in the Figure 3.4 that well-developed of students' writing skills are observed from cycle 1 to cycle 2. However, this results also revealed that making warrant and inferring findings were still hard to be mastered by students, since those skills required critical thinking skills. Therefore, further research will be interesting in investigating the correlation between critical thinking skills and argumentation and writing skills ability. The results show that the development of students' argumentation skills was getting well-developed as a manner of number of SWH implementation. This result further suggesting that the more argument-driven strategies are implemented, the more mastered of students' skill in generating scientific arguments (Figure 4.).

This finding supported the previous research which is finding that the implementation of Argument-driven inquiry (ADI) model has succeeded to improve students' writing and presentation skills [16]. The current result shows that student ability in writing well-developed over time. Students found to be got used to struggle with several aspects of scientific writing. This result is in line with previous research that also found that argument-based strategy (ADI model) incorporated with student's report peer assessment was successful in improving student's writing skills [17].
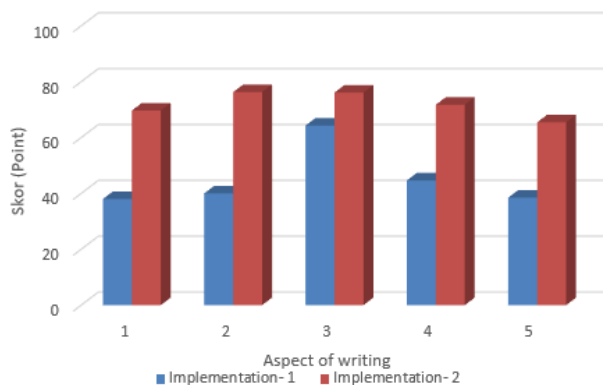

Fig. 4. Students' ability in generating written argument in the experimental group. Implementation-1: rate reaction, Implementation-2: enzymatic rate reaction. Aspect of writing: (1) Making questions, (2) Design their own experiment, (3) Observing, (4) Warrant, (5) Inferring.

IV. Conclusion

The steps of SWH approach required students to make reasonable arguments as the basis of their inquiry, drawing evidence for supporting their claims, and even doing counterclaims according to the other claims. The results of this current study showed that students who were experienced by practising to make immersed argument through SWH approach were able to gain better-developed arguments than those students who lectured by traditional approach. Importantly, the level academic achievement also found to be another variable that could not be ignored in developing students' skills in argumentation. Yet, the performance of argumentation skills in both low and high ability students in the SWH-class group found progressively developed. These findings further suggesting that the SWH approach and other arguments-based approach appear to have been able to support the development of students' argumentation skills in General Laboratory Course.

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