Student worksheet based on inquiry with vee map to improve students' scientific reasoning ability in physics learning in senior high school

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Abstract. Scientific reasoning is a skill in the 21st century that can be used to see one's ability to hypothesize the results of thought. Scientific reasoning in physics can be seen from practicum activities and results that contain questions that follow several indicators of scientific reasoning. But so far it hasn't been done well. One effort to improve scientific reasoning ability is to use guided inquiry learning models. But in practice, there are still difficulties experienced by students. Therefore, the researcher offers a solution by creating an inquiry-based student worksheet based on the Vee map. Student worksheets contain concepts and methodologies that are interrelated to make it easier for students to answer the given problem. This study uses a qualitative method with instructional design to develop worksheets for students conducted in senior high school MIPA XI classes. Based on the results of the study, it can be concluded that the inquiry-based student worksheet assisted by the Vee map can be used for inquiry-based learning, so it is expected to improve the scientific reasoning abilities of senior high school physics students.

1. Introduction

The latest curriculum in Indonesia is the 2013 curriculum, where in the standard education process, teachers are required to apply three learning models and two learning approaches. The learning approach in question is a scientific approach, which includes observing, asking, reasoning, trying and forming networks [14]. However, based on the results of the 2015 Program for International Student Assessment (PISA) ranking from OECD data [13], Indonesia ranked 64 out of 72 countries in the science category. So that science and science performance of students in Indonesia is still relatively low. Thus more effort is needed to be able to help students build high-level skills in science, one of which is scientific reasoning. Scientific reasoning is a thought process or activity that is used to solve problems based on facts or concrete evidence so that students are able to draw conclusions [19].

Scientific reasoning abilities are expected to increase if students are able to build their own knowledge [17]. And according to [18] inquiry learning can improve scientific reasoning abilities. So according to [9] the guided inquiry learning model is able to develop students independently and positively influence the learning process to improve the ability of scientific reasoning. However, the obstacle of the guided inquiry learning model according to [4] is the lack of tools that encourage students to reflect and discuss when students are independent. Thus, [10] provided a solution by emphasizing the use of scaffolding.asserts that the need for scaffolding or which can be used to link concepts, knowledge, facts and process skills through scientific reasoning. And previously there was scaffolding in graphic form in scientific investigations [12]. But according to [20] the

use of scaffolding in graphics is less able to help students. One example of scaffolding is the Vee map that is able to link the processes of science, knowledge and science products [12]. The Vee map consists of two interacting sides which include concepts and methodologies. The benefits of the Vee map according to [14] are the possibility of students to be active in the learning process. So scaffolding like the Vee map has the potential to become a useful, practical and useful learning tool in the classroom.

Scaffolding-based student worksheets are a type of teaching material that uses gradual assistance so students can complete their own assignments, assistance will be eliminated if students have shown an increase in skills to be achieved [3]. The application of scaffolding on student worksheets in inquiry activities can help students only enter the information needed through the scaffolding provided [2]. Besides scaffolding can improve their conceptual understanding of physics material. According to [8] Vee map is similar to a scaffolding diagram which is one of the procedural scaffolding in the form of a diagram that connects claims, evidence, and conclusions. Diagram V helps students connect science concepts and design. Based on the description above, important scientific reasoning abilities are owned by students but are still rarely trained in schools so researchers intend to conduct research to practice these abilities. The formulation of the problem in this study is how are the steps in the inquiry-based student worksheet accompanied by a Vee map to improve the scientific reasoning abilities of physics students in senior high school? So this study aims to describe the steps on a worksheet of students who are able to practice their scientific reasoningabilities.

2. Methodology

This type of research is a qualitative research with instructional design to develop student worksheets. This student worksheet is equipped with a scaffolding Vee map developed by [11] with several steps. The Vee map application on this student worksheet is presented in each successive section. Before entering on the Vee map, students fill in the focus questions first. Then proceed on the conceptual side which includes theories, principles, concepts and events or experiments. And proceed to the methodology that starts in the notes or data, transformation and up to knowledge claims, which are the answers to the focus questions. Where every part on the Vee map is similar to the scientific reasoning indicator. So that the Vee map can improve scientific reasoning in physics students in secondary schools. This student worksheet is intended for senior high school Mathematics and Natural Sciences students with static fluid subject matter which includes hydrostatic pressure, Pascal's law and Archimedes law. This research is to improve students' scientific reasoning abilities, so that they can fulfill one of the competencies in the 21st century. The instrument uses a form of comments or notes from the expert and an assessment of the parts of the student worksheet that still need to be corrected or recorded by the expert as a basis for revision.

3. Results

In this study, the resulting product is in the form of Student Worksheets that are equipped with scaffolding vee maps useful to help improve scientific reasoning abilities, because so far the student worksheets that are used are still rarely specialized about scientific reasoning abilities but only to see learning outcomes as in worksheet based on collaborative creativity which aims to improve students' scientific arguments [15]. There is also a mind mapping based student worksheet aimed at knowing the strength of student retention [7], thus the researcher wants to develop student worksheets that integrate scaffolding by directing scientific reasoning abilities. Inquiry-based student worksheets assisted by Vee map on static fluid material are media that facilitate students in the learning process and are used to practice the scientific reasoning abilities of physics in high school. The following is a form of the Vee map according to [11] concerning hydrostatic pressure material:

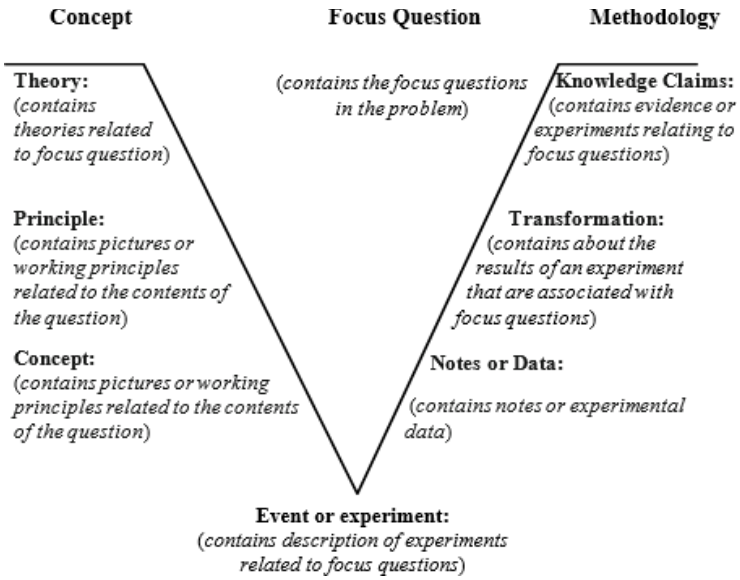


Figure 1. Vee map

But to work on an inquiry-based student worksheet accompanied by this Vee map, first the Vee map is cut into each stage, including:

3.1. First problem stage

At first stage, a problem is presented wherestudents are expected to beableto defend the concept of theory even under different circumstances. To work on this problem, students are expected to analyze the picture first and then understand the questions given.

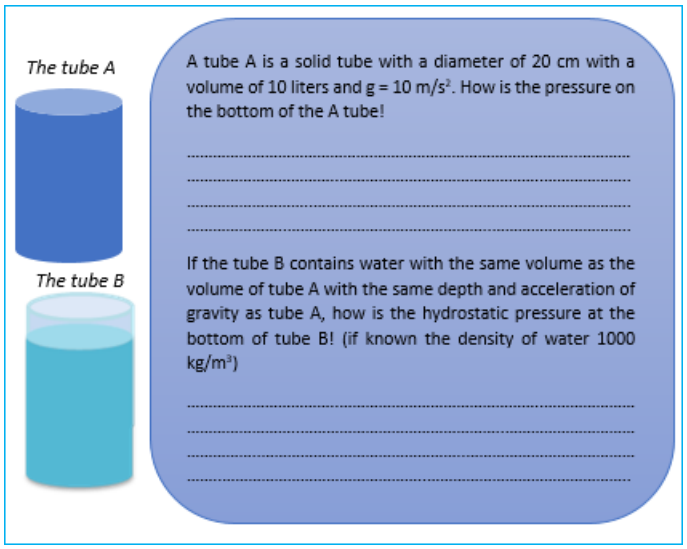


Figure 2. Problems in the first stage

To answer the question above, students were assisted by a Vee map, where separately using the Vee map the researcher cuts the Vee map in the theory section. Because students to work on problems in stage 1 are required to know the meaning and formula of the pressure first.

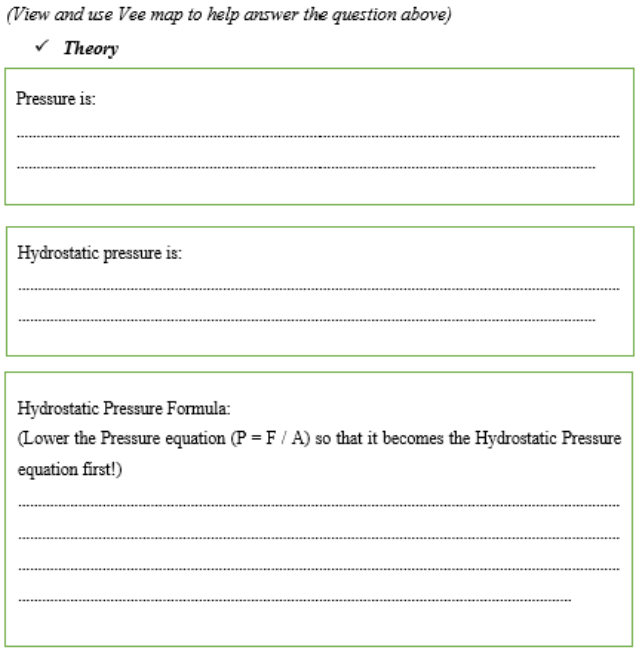
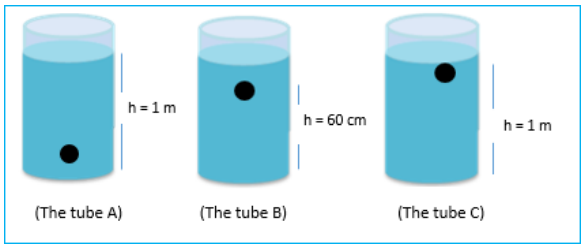


Figure 3. Vee map (theory)

Presentation of problems on student worksheets at this conservation stage can make students able, to retain knowledge, that even though the appearance of the object changes, certain characteristics of an object remain the same. So that this is in accordance with the indicators of scientific reasoning according to [6] on conservation reasoning, namely the ability to retain knowledge that even though the appearance of an object changes, but certain properties of an object remain thesame.

3.2. Second Problem Stage and Formulation of the Hypothesis

At second stage, a new problem is presented about the matter of comparing the same events but the conditions are different. To work on this problem, students are expected to understand the description of events in the problem first. At this stage in accordance with indicators of scientific reasoning ability according to [6] namely the ability to determine and compare ratios. Proportional thinking can be conceptualized by finding broad variables as a matter of comparison with intensive variable.



What is the high level of hydrostatic pressure? In which tube is the biggest hydrostatic pressure? Why is that?

Figure 4. Problems in the second stage

To answer the question above, students were assisted by a Vee map, where to use the Vee map the researcher cuts the Vee map in the principle section. This principle contains illustrations or experiments regarding hydrostatic pressure material so students know more about the application in dailylife.

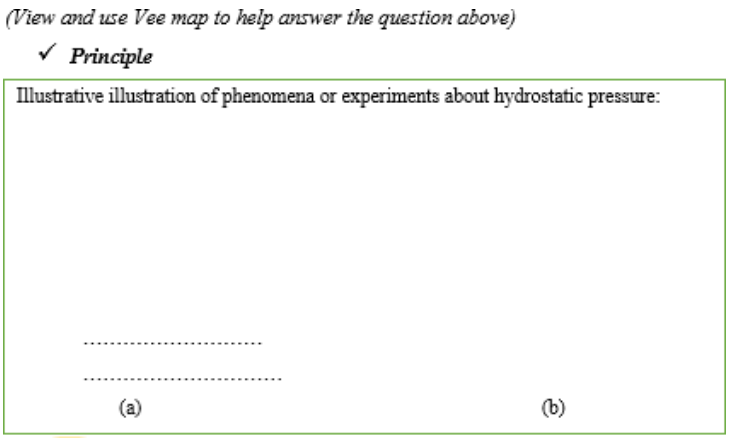


Figure 5. Vee map (principle)

But after the help of Vee map above, students are expected to be able to make hypotheses with illustrations in everyday life so that students are able to find out temporary answers to problems that must be verified by experiment. Examples of this hydrostatic pressure material students are given problems include stage 1 and stage 2 contained in the fluid and its relation to the depth of an object. So students are expected to be able to know the effect of depth on a hydrostatic pressure.

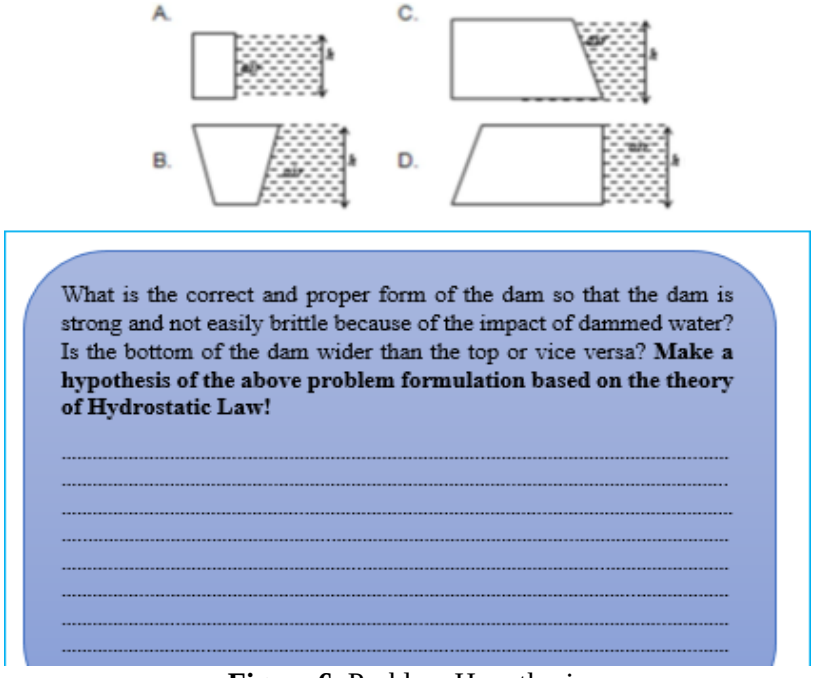


Figure 6. Problem Hypothesis

To answer the question above, students were assisted by a Vee map, where separately using the Vee map the researcher cuts the Vee map in the concepts and events or experiments section. In the event or experiment students are also asked to fill in the experiment steps related to the hydrostatic pressure material

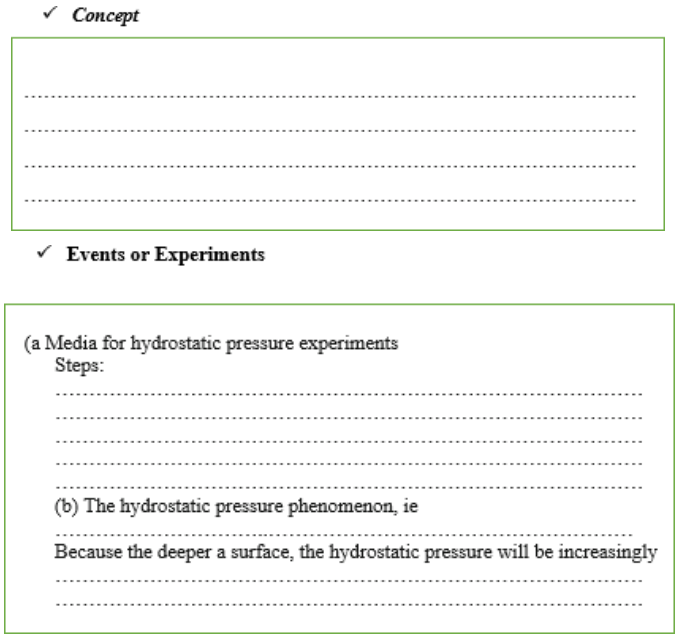


Figure 7. Vee map (concepts and events or experiments)

To prove the problem above, students are expected to do proof, that is by conducting experiments or simple experiments. The experiments concerned factors that influence hydrostatic pressure. Where the steps of the experiment, among others, by punching a bottle of mineral water with several holes with different heights then filled with water. Next the students watched the shower coming out of the hole. Presentation of problems on student worksheets at this conservation stage can make students betterable to determine and compare ratios.

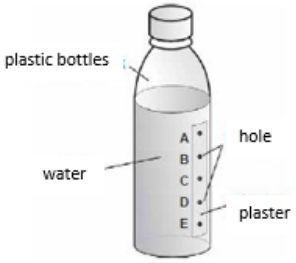
3.3. Variable Control Stage

At this stage, students are expected to be able to determine the variables that influence the above experiment. After knowing each of the existing variables, then students conduct experiments as above but with different control variables. Namely replacing water fluid with oil, then students are asked to observe the shower water coming out will be the same as the previous experiment. So at this stage of variable control it is expected that students will be able to control variables including controlling dependent and independent variables that influence the hypothesis test.

3.4. Experiment and Data Collection Stage

At this stage, students are asked to collect data through experiments that have been carried out in the previous stage, which includes the distance of the shower produced and the amount of density of the liquid used. So that at this stage in accordance with the indicators of scientific reasoning according to [5] namely correlational thinking ability in determining whether two variables or two events are related or not. This correlational thinking determines the strength of the interrelationships between variables.

a. Prepare 1 large bottle of mineral water
b. Pour a mineral water bottle with a match of 3 holes with a distance of 5 cm between the holes.

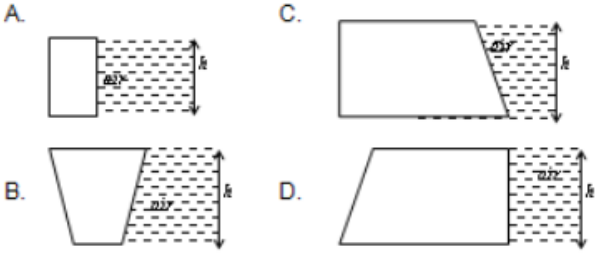


c. Pour the water into the bottle until it's full.
d. Observe a shower of water coming out of the hole.
e. Mark the distance of the shower that comes out of the hole by writing the boundary mark (write with marker).
f. Write the difference in shower spacing!
(A) …… cm
(B) …….. cm
(C) …….. cm
(D) …….. cm
(E) …….. cm

Figure 8. Experiment table

3.5. The Compare Stage

At this stage, students are expected to be able to repeat knowledge by comparing hypotheses of knowledge obtained from theory with the results of experiments conducted.



What is the correct and proper form of the dam so that the dam is strong and not easily brittle because of the impact of dammed water? Is the bottom of the dam wider than the top or vice versa? **Give a conclusion and its relationship with the material Hydrostatic Law!**

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Figure 8. Problems in the Compare Stage

To answer the question above, students were assisted by a Vee map, which separately uses the Vee map the researcher cuts the Vee map in the transformation and knowledge claims section.

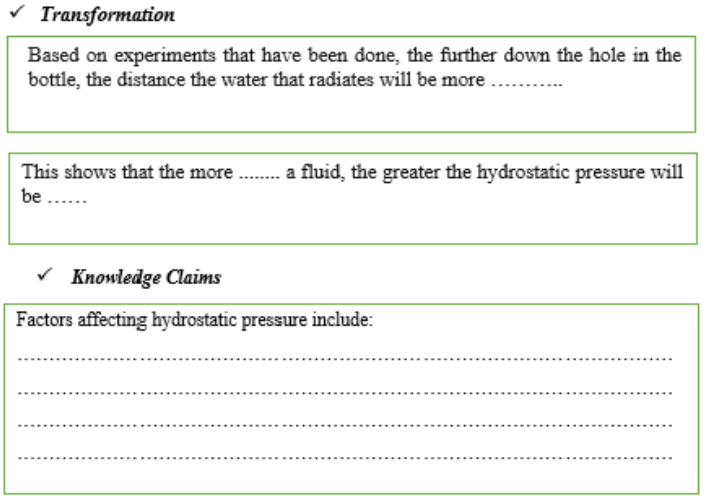

Figure 9. Vee map (transformation and knowledge claims)

Presentation of problems on student worksheets at this probabilistic stage can make students able, to think probabilistic as situations that produce certain results when repeated in the same situation in a larger context. So according to the indicators of scientific reasoning according to [6] namely probabilistic thinking as a situation where it produces certain results when repeated in the same situation in a larger context.

3.6. Formulate a Conclusion Stage

At this stage, students are expected to be able to fill in the sentence that has been provided, which involves learning that has been done in the previous stages.

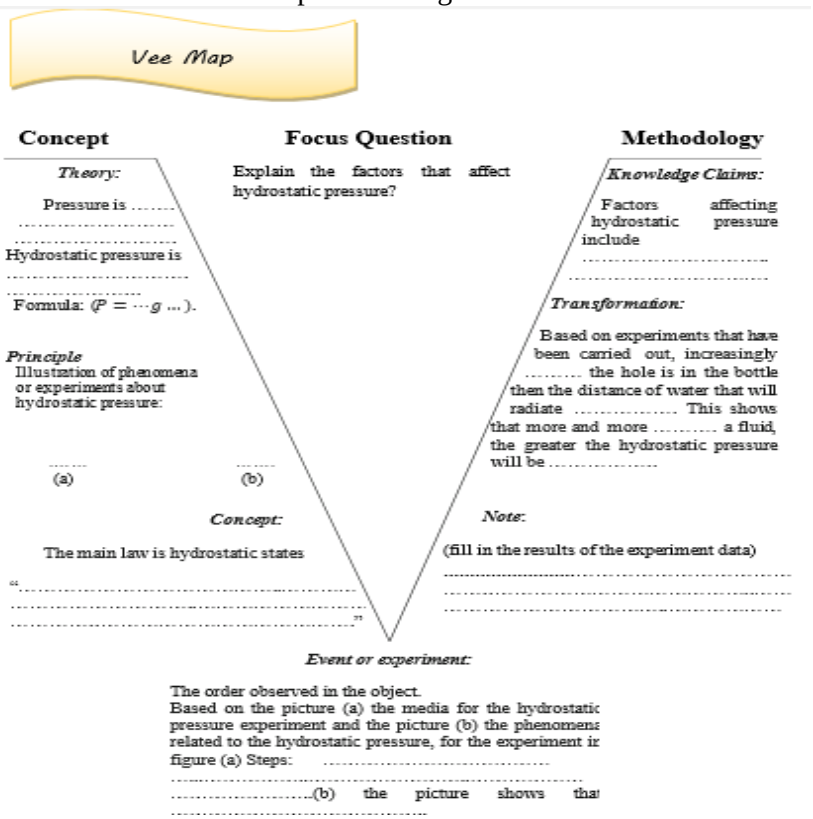

Figure 9. Last stage

Presentation of problems on student worksheets in this stage can make students able to test hypotheses and deductive reasoning, namely reasoning to draw conclusions. So, deductive hypothesis stage students are able to develop and organize solutions to overcome a problem. It is also in accordance with the indicators of scientific reasoning according to [6] namely hypothesis reasoning namely reasoning to test hypotheses and deductive reasoning namely reasoning to draw conclusions. Thus, hypothetical- deductive reasoning as a characteristic of the process of reasoning that results in the development and organization of possible solutions to overcome problems in every dominant step of life. Based on the steps of the inquiry-based student worksheet Vee map above is expected to be used to improve students' scientific reasoning abilities. Where this is in accordance with the statement of [16] that the Vee map will be able to deliver students to find the relationship between knowledge and scientific work. The discovery process can be guided by several questions that must be answered by students. The final section will serve to issue opinions based on the results of experimentsconducted.

4. Discussion

The researcher wants to develop student worksheets that integrate scaffolding by directing scientific reasoning abilities. Inquiry-based student worksheets assisted by Vee maps on static fluid material are media that facilitate students in the learning process and are used to practice the scientific reasoning abilities of physics in high school. Student Worksheets are used by students in the inquiry process in groups. Students write the results of the inquiry activities on the Student Worksheet which is the final result of the guided inquiry learning activities. Student worksheets given to students contain a map of Vee that guides students to reason by answering the questions that have been presented, thus forming knowledge that will be written on the Student Worksheet practice. The Vee map will help students understand how concepts and methodologies can be interrelated [1] The components of an inquiry-based Student Worksheet accompanied by Vee maps include: the first problem stage, the second problem stage and the formulation of hypotheses, the variable control stage, the experimental and data collection stage, the compare stage, and formulating the conclusion stage.

5. Conclusion

Based on the discussion data, it can be concluded that the inquiry-based student worksheet with the Vee map consists of first problem stage, second problem stage and formulation of the hypothesis, variable control stage, experiment and data collection stage, the compare stage, and formulate a conclusion stage. This student worksheet supports scientific reasoning indicators developed by [6] which include conservation reasoning, proportional reasoning, identification and collection of variables, correlation reasoning, probabilistic reasoning and hypothesis-deductive reasoning. The results were obtained from references from various sources, inquiry-based student worksheets assisted by Vee map can be used to improve the scientific reasoning of physics students in high school.

Acknowledgments

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