Pre-service Science Teachers’ Conceptual Understanding of Integrated Science Subject: A Case Study

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Abstract. The integrated science curriculum has been implemented in Indonesia since 2013. The purpose of this study is to investigate pre-service science teachers’ conceptual understanding of integrated science subject. This research is a case study. Data were analyzed descriptively. The sample used in this research is 44 pre-service science teachers from one of the universities in Indonesia. Samples are taken from 2 classes in science education majors who have never taken an integrated science subject. The result of this research is the initial conceptual understanding of pre-service science teachers on five topics: simple machines, energy, respiratory system, sound, and global warming are still low and not as expected. This is because most pre-service science teachers still tend to answer a question based on within single disciplines. They have not shown the ability to answer questions by connecting from different disciplines (interdisciplinary). Pre-service science teachers still have misconceptions on the global warming topic. The results can show how the initial mindset of pre-service science teachers in integrated science, so that lecturers can prepare learning strategies or literature sources to teach integrated science subject at the university level.

1. Introduction

Integrated science is a science that integrates different disciplines such as Biology, Microbiology, Ecology, Physics, Chemistry, Earth Science, and Astronomy. Integrated science explains the overlapping or relationship of one discipline with another [1]. Integrated science curriculum has been implemented in Indonesia from 2013 until now [2]. In addition, the integrated science curriculum has also been applied to various countries such as in the United States of America, China and Jamaica [3-5].

Researches related to integrated science have been carried out. Those studies investigated the comparison of integrated approaches versus non-integrated approaches through reviews of various literature [6]; the use of integrated instruction to reduce students’ cognitive load [7]; the development of integrated science curriculum in schools [8]; the status of integrated science instruction in schools [9]; lastly, the implementation of integrated science in low socioeconomic schools [10]. However there have been several studies related to integrated science, no research has investigated pre-service
science teachers’ initial conceptual understanding in Indonesia. This research investigated the conceptual understanding of five science topics: simple machines, energy, respiratory system, sound and global warming. In addition, the study also detected misconceptions on the topics. The purpose of this study is to investigate pre-service science teachers’ conceptual understanding of integrated science subject.

2. Method
This research is a case study [11]. The data were analyzed using the descriptive method. The sample used in this research is 44 pre-service science teachers at a university in Bandung, Indonesia. The sample consisted of 4 male and 40 female. The sample is from two different international classes (first and second year) in the science education department. International classes are classes with English as the medium of instruction. The sample students have never taken the integrated science course. The age of the sample is ranging from 17-20 years. Data from the sample used can be seen in table 1.

|       | 1st class | 2nd class | Total | Percentage |
|-------|-----------|-----------|-------|------------|
| Female| 21        | 19        | 40    | 90.90%     |
| Male  | 1         | 3         | 4     | 9.10%      |
| Total | 22        | 20        | 44    | 100%       |

The test instrument in this study was developed by the researchers and validated by an expert in the field. The instrument consists of five topics: simple machines, energy, respiratory system, sound, global warming. There are five general questions so that the samples were able to answer according to their initial perception. They were allowed to answer the questions based on Physics, Biology, Chemistry or integration of several disciplines (interdisciplinary). Specifically for the answers about global warming, misconception analysis was also conducted; this is due to some misconceptions found on the topic. The results of the data analysis were analyzed descriptively to investigate pre-service science teachers’ initial conceptual understanding of integrated science subject.

3. Result and Discussion
The results of data analysis consist of five topics: simple machines, energy, respiratory system, sound and global warming. The result of answers about simple machines can be seen in Figure 1; energy in Figure 2; the respiratory system in Figure 3; sound in Figure 4; and global warming in Figure 5. Pre-service science teachers’ conceptual understanding of simple machines can be seen in Figure 1 below.
Figure 1 shows conceptual understanding data on simple machines. The question asked for pre-service science teachers on the topic of simple machine is "What do you know about simple machines?". The result of data analysis shows that pre-service science teachers who answered questions based on Physics are 97.73% (43 pre-service science teachers) and those who answered by integrating Physics and Biology amounted to only 2.27% (1 pre-service science teachers).

The question can actually be answered by integrating Physics and Biology. In Physics, simple machines can be described as the lever, pulley, inclined plane, wheel, and gear. In Biology, levers in the human body can also be explained; the neck is an example of a second-class lever. However, the result shows that only 2.27% (1 pre-service science teachers) was able to answer by integrating Physics and Biology. This result indicates that pre-service science teachers still consider simple machines as a topic only found in Physics. Pre-service science teachers’ conceptual understanding of energy can be seen in Figure 2 below.

Figure 2. Conceptual Understanding Data on Energy
Figure 2 shows conceptual understanding data on energy. The question asked for pre-service science teachers on the topic of energy is "What do you know about energy?". The result of data analysis shows that pre-service science teachers who answered questions based on Physics were 36.36% (16 pre-service science teachers); Biology 2.27% (1 pre-service science teachers); Chemistry 2.27% (1 pre-service science teachers); by integrating Physics and Biology 34.09% (15 pre-service science teachers); by integrating Chemistry and Biology 34.09% (15 pre-service science teachers); and by integrating Physics, Chemistry and Biology 18.18% (8 pre-service science teachers).

The question on the topic of energy can actually be answered with three areas of science: Physics, Chemistry, and Biology. In Physics, the question can be explained by mentioning potential energy, kinetic energy, and mechanical energy. In Biology, energy is related to plants converting the radiant energy of sunlight into the chemical energy necessary to sustain life for organisms at every trophic level. In Chemistry, it is related to stored chemical energy in fossil fuels (coal, gas, and oil) which is converted to heat energy during the burning process. However, based on the result of data analysis, only 18.18% (8 pre-service science teachers) was able to answer by integrating Physics, Chemistry, and Biology. This result indicates that most pre-service science teachers still consider that the topic of energy can only be explained by only one or two fields of science. Pre-service science teachers’ conceptual understanding of the respiratory system can be seen in Figure 3 below.

Figure 3 shows the conceptual understanding data on the respiratory system. The question asked for pre-service science teachers on the topic of the respiratory system is "Explain the process of the human respiratory system!". The result of data analysis shows that pre-service science teachers who answered the question based on Biology are 95.45% (42 pre-service science teachers) and students who answered by integrating Physics and Biology amounted to 4.45% (2 pre-service science teachers).

The question can actually be answered with Physics and Biology. In Physics, the process of the respiratory system in human can be explained by Boyle's Law with the formula of $P_1 V_1 = P_2 V_2$. In Biology, the human respiratory system can be explained by sequences: the process of O$_2$ entering a human's body from the nose until it comes out as CO$_2$. However, only 4.45% (2 pre-service science teachers) was able to answer by integrating Physics and Biology. This result indicates that pre-service science teachers still consider the respiratory system as a topic that can be explained only by one field of science which is Biology. Pre-service science teachers’ conceptual understanding of sound can be seen in Figure 4 below.
Figure 4 shows the conceptual understanding data on sound. The question asked for pre-service science teachers on the topic of sound is "What do you know about sounds?". The result of data analysis shows that pre-service science teachers who answered the question based on Physics are 61.36% (27 pre-service science teachers) and who answered by integrating Physics and Biology amounted to 38.64% (17 pre-service science teachers).

The question on the topic of sound can actually be answered with Physics and Biology. In Physics, sound can be explained by the frequency of sound ($f$), wavelength ($\lambda$), period ($T$), and by the formula of measuring ocean depth by utilizing ultrasonic sound. In Biology, any living thing that can hear ultrasonic and infrasound sounds can be explained, by mentioning the phenomenon of bats not hitting objects in front of them during night flights. However, only 38.64% (17 pre-service science teachers) was able to answer by integrating Physics and Biology. This result indicates that pre-service science teachers still consider sound as a topic that can be explained only based on Physics. Pre-service science teachers' conceptual understanding of global warming can be seen in Figure 5 below.
Figure 5. Conceptual Understanding Data on Global Warming

Figure 5 shows conceptual understanding data on the global warming topic. The question asked for pre-service science teachers on the topic of global warming is "Explain the process of greenhouse effect!". The result of the data analysis shows that pre-service science teachers who answered questions based on Physics are 61.36% (27 pre-service science teachers); by integrating Physics and Chemistry 29.55% (13 pre-service science teachers); and by integrating Physics and Biology 9.09% (4 pre-service science teachers).

The question can actually be answered with Physics, Chemistry, and Biology. In Physics, energy ($E$), frequency ($f$), and wavelength ($\lambda$) of infrared and ultraviolet light can be elaborated. In addition, the temperature of the earth gets hotter can also be explained with Physics formulas. In Biology, the question can be answered by mentioning the impact of the greenhouse effect on living things and the environment. In Chemistry, there are gases that affect the greenhouse effect such as $CO_2$, $H_2O$, $N_2$, $CH_4$. However, no pre-service science teachers (0%) answered by integrating Physics, Chemistry, and Biology. These results indicate that pre-service science teachers’ understanding of global warming is limited to one to two disciplines only. Based on the data analysis, misconception on the topic of global warming was also found. Pre-service science teachers’ misconception data can be seen in Figure 6 below.

![Global Warming Graph](image)

**Figure 6. Misconceptions Data on Global Warming**

Figure 6 shows that pre-service science teachers having misconception amounted to 34.09% (15 pre-service science teachers) and those without misconception amounted to 65.91% (29 pre-service science teachers). Students with misconceptions explained that the greenhouse effect occurs because of the number of houses made of glass. The example of an answer with misconception can be seen in Figure 7 below.
Figure 7. Example of a Misconception on the Topic of Global Warming

Based on the data analysis described in Figure 1 to Figure 7, it indicates that the pre-service science teachers’ initial conceptual understanding of the five topics is still relatively low or not as expected. On the topic of simple machines, respiratory system, and sound, the questions should be explained by integrating two different fields of science. However, most pre-service science teachers answered only based on one field of science that is Physics, Biology or Chemistry. Meanwhile, on the topic of energy and global warming, the question should be answered by integrating three different fields of science. However, most pre-service science teachers explained based on only Physics, Biology or Chemistry. In addition, most of the pre-service science teachers answered the question by only integrating two different fields: Physics and Biology, Physics and Chemistry, or Biology and Chemistry only. Pre-service science teachers apparently also have a misconception on the topic of global warming. This is considered dangerous because after graduating from Science education department, these students are expected to become teachers for junior high school students. If wrong concepts are taught, there will be a major impact on the quality of learning for their students in the future.

Pre-service science teachers’ conceptual understanding in Indonesia is still not as expected. This is assumed due to the implementation of the 2013 curriculum which has been running for only 4 years. Pre-service science teachers have never studied science in an integrated way because the curriculum applied today is different than the one they studied when they were in junior high school. In junior high school, science was taught separately by dividing it into Physics, Biology, and Chemistry. Moreover, the connection between the three subjects was not taught. However, since 2013, the Indonesian government has adopted an integrated science curriculum at the junior high school level. Therefore, the connection between Physics, Chemistry, and Biology is also taught and explained. The development of an integrated science curriculum has also been conducted in China [8]. The results of this study are in accordance with another research conducted in China which shows that the application of integrated science at the junior level is still not successful [3], despite the fact that integrated science curriculum in China has been applied for two decades. Compared to Indonesia, the application of integrated science curriculum in China is much longer. In addition, the implementation of integrated science at the university level in China is also not satisfactory [9]. The lecturers’ quality is not sufficient enough to teach integrated science subject. The background of the teachers who did not receive integrated science education becomes one of the problems in the application of the integrated science curriculum. These problems related to integrated science must be resolved immediately. Proper implementation of integrated science curriculum will bring a positive impact on the quality of learning; this is consistent with studies suggesting that learning using an integrated approach will result in better achievements in the areas of science and language arts [6]. The problems in the implementation of integrated science are not only found in Indonesia, but also in other countries with the same integrated curriculum.

4. Conclusions
The result of this research is the initial conceptual understanding of pre-service science teachers on five topics: simple machines, energy, respiratory system, sound, and global warming are still low and not as expected. This is because most pre-service science teachers still tend to answer a question based on within single disciplines. They have not shown the ability to answer questions by connecting from different disciplines (interdisciplinary). Pre-service science teachers still have misconceptions on the global warming topic. The results of this study can show the initial knowledge of how the mindset of pre-service science teachers in integrated science, so that lecturers can prepare learning strategies or literature sources to teach integrated science at the university level.

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