Preparing prospective physics teachers to teach integrated science in junior high school

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Abstract. The physics education study program especially prepares its students to teach physics in senior high school, however, in reality many its graduates have become science teachers in junior high school. Therefore introducing integrated science to prospective physics teachers is important, because based on the curriculum, science in the junior high school should be taught integratedly. This study analyzed integrated science teaching materials that developed by prospective physics teachers. Results from this study showed that majority of the integration materials that developed by the prospective physics teachers focused on topic with an overlapping concept or theme as connecting between two or three subjects.

1. Introduction

Recently the term integrated learning, included integrated science learning, is widely used in Indonesian educational fields, especially in elementary and junior high school [1, 2]. Based on the Curriculum 2013, science learning in primary and junior high schools is provided in an integrated-thematic. This approach requires the ability of teachers, whereas not all science teachers in junior high school are prepared from an integrated science teacher education.

In general, integrated learning has been widely discussed by Fogarty [3], who revealed ten ways or models to integrate curriculum. According to You [4], integrated learning could be implemented by using an interdisciplinary approach to integrate two or more subject areas into a meaningful association to enhance and enrich learning within each subject area. Why an interdisciplinary approach is needed? Because science is complex. The best way to learn and perceive complex phenomena of the real world should be based on an interdisciplinary approach [4].

Physics, biology, and chemistry subjects in the science discipline are not isolated from one and others. Separation will create only an artificial way to teach science, which does not reflect its true nature. Therefore, the complexity of the natural system or its corresponding scientific problems necessitate interdisciplinary understanding informed by multiple disciplinary backgrounds.

Integrated learning has long enough been introduced in U.S. This is shown in several science standard documents, such as the National Science Education Standards (NSES) issued by the National Research Council (NRC) [5]. NRC stated that curricula often will integrate topics from different subject-matter areas, such as life and physical sciences, and from different content standards, such as life sciences and sciences in personal and social perspectives. Furthermore, NRC declared that schools must restructure schedules so that teachers can use interdisciplinary strategies [5].

Integrated science learning has also been applied in Asian countries, such as China and Korea. In China, the State Council of China [6] completed a curriculum reform in elementary and middle
schools nationwide. The new curriculum strengthened the links between different subjects and the connection between course content and students’ real-life experiences. Similarly in Korea, the Korean government has launched a reformed curriculum in which the government heavily promoted the integration of school science with other disciplines through Science, Technology, Engineering, Arts, and Mathematics (STEAM) education [7, 8].

Nowadays, the swing of the educational pendulum moves in a direction of integrated science learning. Does it go as successful as expected? Most science education researchers have realized that science lessons today focus in learning in discipline-based structures, which allows students to have limited and fragmented knowledge [9, 10].

Sun et al. [11] also detected major problems in the instruction of integrated science at the secondary level in China. Their findings revealed that students were provided with limited opportunities for participating and engaging in learning as science teachers were dominant in classroom talk, and teachers emphasized on the integration of knowledge within one subject (within-subject knowledge), but not the integration of knowledge between subjects (cross-subject knowledge). According to Sun et al. [11] and also Zhang and He [12], teachers were inadequately competent in designing and delivering science, technology and society content, scientific inquiry and scientific experiments, which also affected the quality of instruction on integrated science.

Similarly in Indonesia, science learning in junior high school tends discipline-based structures. This happens because not all science teachers in the junior high school are graduates from a science teacher preparation program, such as science education study program, but many of them have physics, biology, or chemistry education background. Science teachers with physics education background usually have difficulties in delivering biology and chemistry topics, especially in delivering integrated science materials [2]. Likewise, science teachers with biology education background have difficulties in teaching chemistry and physics, and so on.

Other problems encountered in junior high school, the science learning have not already fully implemented the scientific approach as advocated by the Curriculum 2013 [13]. Many factors cause this to happen, including because the teacher has not understood the scientific approach. In fact, this scientific approach is closely related to the implementation of integrated science learning.

Therefore, improving the quality of teachers including prospective science teachers should be pursued. Introducing the integrated science learning to prospective physics teachers is needed. In order to achieve this purpose, the “Integrated Science Learning Development” course was designed to prepare the prospective physics teachers to teach integrated science learning in junior high school.

2. Methods
This research used qualitative approach with the subject was students of Integrated Science Learning Development. Integrated Science Learning Development is a special course which is only delivered for students of the third year physics teacher candidates (or prospective physics teachers). The research was focused to describe the integrated science teaching material that produced by students.

In the lectures of Integrated Science Learning Development which was attended by eleven students, they were assigned to design integrated science materials. The collected tasks were analyzed qualitatively, that were identified and classified to see the tendency of their integration model.

In addition, the prospective physics teachers also presented their products and discussed them in front of the class. Furthermore, each the prospective physics teacher developed their products in the form of a teaching plan. Information obtained by researchers from the presentations, discussions, and teaching plan was used to confirm and strengthen the results of identification of the trend of integrated models designed by students.

3. Result and Discussion
Each the prospective physics teacher produced an integrated science material for junior high school, so that all collected eleven materials. Each product was analyzed qualitatively by coding or classifying base on topic or theme, variety of the related subjects or disciplines, and focus of integration. Based on
the results of this classification, the pattern of integration can be obtained as fragmented, connected, nested, sequenced, shared, webbed, threaded, or integrated model [3]. The results of the analysis of these products are shown in Table 1.

Table 1. Classification of the integrated science teaching material topic that produced by students

| No. | Topic/Theme         | Related Subjects                        | Model                        |
|-----|---------------------|-----------------------------------------|------------------------------|
| 1   | Heat                | physics, biology, chemistry (focus on physics) | The integrated model         |
| 2   | Fluid               | physics, biology, chemistry (focus on physics) | The integrated model         |
| 3   | Photosynthesis      | physics, biology, chemistry (focus on biology) | The integrated model         |
| 4   | Transportation systems in living things | physics, biology, chemistry (focus on biology) | The integrated model         |
| 5   | Thermodynamics      | physics, biology, chemistry (focus on physics) | The integrated model         |
| 6   | Sound               | physics, biology, chemistry (focus on physics) | The integrated model         |
| 7   | Optics              | physics, biology, chemistry (focus on physics) | The integrated model         |
| 8   | Skeletons and muscles | physics, biology, chemistry (focus on biology) | The integrated model         |
| 9   | Energy              | physics, biology, chemistry (focus on all subjects or common theme) | The integrated model         |
| 10  | Electricity         | physics, biology, chemistry (focus on physics) | The integrated model         |
| 11  | Motion              | physics, biology, chemistry (focus on physics) | The integrated model         |

Table 1 shows seven integrated materials compiled by prospective physics teachers with a major focus on the discipline of physics, especially on topics: heat, fluid, thermodynamics, sound, optics, electricity, and motion. Three materials on biological disciplines with topics are: skeletons and muscles, photosynthesis, and transportation systems in living things. The rest, a matter of energy that is a common theme widely used in physics, biology, and chemistry.

In the three main material groups, students use overlapping concepts, so that physics, biology, and chemistry become interrelated. For example, on the topic of photosynthesis, students use the concept of light as an overlapping concept between biology and physics, and the concept of carbohydrates as an overlapping concept between biology and chemistry. On the topic of optics, students use the concept of light to relate between physics, biology, and chemistry, while the concept of a lens to link physics and biology. On the topic of energy, students use energy as an overlapping concept (common concept) between physics, biology, and chemistry.

The results of qualitative analysis of the eleven students’ products can be identified that they have some similarities. First, all products focus on topics, i.e. seven topics of physics, three biology topics, and the other is common topic. The topic is become the main focus of integration. Second, all products use an overlapping concept to connect between subjects.

In the context, physics, biology, and chemistry, respectively, are viewed as a single independent discipline, the integrated science materials designed by the prospective physics teachers tend to be like the integrated model [3]. In these integration materials, topics or themes serve as the main focus,
therefore these integration materials compiled by the prospective teachers can be called the topic-focused integrated model.

There are two types of the topic-focused integrated models produced by the prospective teachers (Figure 1). First, a model that focuses on the topic of one subject or discipline, such as photosynthesis which is a biology topic (Fig. 1 (a)). Second, a model that focuses on common topics or themes, such as energy which is the topic of the three disciplines (physics, biology, and chemistry) (Figure 1 (b)).

Figure 1 (a) shows that on the topic of photosynthesis, the prospective physics teachers use the concept of light to connect biology and physics, and the concept of carbohydrates to link between biology and chemistry. While Figure 1 (b), the prospective teachers use topic or theme of energy as a common concept or theme that links physics, biology, and chemistry.

![Diagram of topic-focused integrated model]

Figure 1. The topic-focused integrated model (a) Photosynthesis (biology topic); (b) Energy (common topic/theme)

4. Conclusion

This study showed that majority of the integration material that developed by the prospective physics teachers focus on topics of physics, biology, or chemistry, and few of that base on common theme. Because of the topic-focused integration, the model of integration material is called the topic-focused integrated model. In this model, the prospective physics teachers used an overlapping concept to connect between two subjects or two disciplines, or used a common theme to connect between three subjects or disciplines.

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