KnE Social Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

Scientific Explanation Skills of Prospective Biology Teachers

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Abstract.
This article investigated prospective biology teachers' skills in compiling science explanations through writing and pictures to support their science explanations. This study involved 15 prospective biology teachers as the research sample. A test was constructed to measure their skills in writing science explanations. In this test, prospective biology teachers were asked to explain the concept of static electricity in living things. To analyze the data, we used the structure of a scientific explanation, which comprises three primary components: premise – accepted knowledge that provides the basis of the explanation, reasoning – logical sequences that follow from the premise, and outcome – the phenomenon to be explained. The reasoning component of the prospective biology teachers' skills in presenting visual representations was poor. This finding supports the necessity of developing the skills of future biology teachers in writing science explanations.

Keywords: scientific, explanation skills, prospective teachers, biology

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Published: 26 April 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

One of the goals of science education is to prepare students to synthesize and evaluate scientific explanations [1] [2]. Scientific explanation is an important part of scientific literacy [3]. "Framework For K-12 Science Education" states that teaching students to use a language is more effective through compiling scientific explanations, making evidence-based arguments, obtaining information, evaluating, and conveying information [1] as a part of science communication skills [4–6]. The learni objective, stated in PISA (Program for International Student Assessment) framework is to develop students' skills in constructing and interpreting science explanations based on evidence and models, as well as evaluating students' own or other people's explanations. The objective is to assess the logical relationship between evidence and conclusions [7, 8]. Students

make explanations to gain understanding in explaining phenomena and provide personal understanding of the explanations obtained from textbooks, teachers, or other informal sources. Answers to various questions were also obtained based on students' understanding of scientific phenomena proposed by the teacher, both spoken and in writing [9]. Scientific explanation plays a central role in a person in seeking, knowing, understanding the world, studying, and communicating scientific phenomena [10]. Skills in building scientific explanations can change the epistemic view of science. Scientific explanation in scientific investigation can provide valuable experience for someone [11].

Various results of study show that there is a gap in scientific explanation learning in the classroom [3, 12]. Students' scientific explanations are often different from explanations by scientific community in general [11]. The ability of children, in this case as students, and adults in constructing explanations does not arise naturally [12]. Students have difficulty providing sufficient evidence for their claims [13]. Students should be able to do scientific reasoning in understanding the development of the world today [14]. The results of various international studies show that students in Indonesia have difficulty in constructing scientific explanations [14, 15]. On the other hand, teachers often provide learning that is not integrated with everyday life [16]. Teachers have difficulty in determining science learning steps that is practical to integrate science into the context of daily life [2, 17, 18]. This condition demands the ability of teachers to provide scientific explanations to students. Teachers should provide activities that can stimulate the integration of knowledge in order to explain scientific phenomena and solve life problems to students so that students can understand various theories with real evidence [3, 14, 15, 19, 20]. Scientific explanation is part of scientific literacy [1, 21]. Therefore, teachers should have professional competencies related to scientific literacy [22] in terms of scientific explanation. Professional competencies that must also be prepared for prospective biology teachers.

One strategy to build a scientific explanation consists of three components, namely: Premise - Reasoning - Outcome (PRO). Premises are accepted knowledge that provides a basis for explanation. Reasoning is a logical sequence that follows a premise. Outcome is the phenomenon described [3]. Several modes of representation can be used to build scientific explanations [9]. Researchers propose and agree on the use of multimode representations that can provide students with a deeper understanding of complex science concepts [23, 24]. Therefore, we need instructors who can assess skills and provide appropriate scaffolding for students' Scientific Explanation Skill . Scaffolding is embedded within multimode representations into the PRO structure which can improve

explanation skills and understanding of science concepts. The embed is done in the form of PRO and Visual Representation (VR).

Before implementing appropriate learning strategies to improve science explanation skills, it is necessary to conduct a preliminary study of scientific explanation skill to the prospective biology teachers. The preliminary study is done as a preparation for the prospective biology teachers to explain scientific phenomena to students. One of the high school biology learning materials that are considered difficult by high school students and teachers is the regulatory system, including the nervous system [16]. Based on the high school biology curriculum syllabus, nervous system learning materials are taught to class XI students [25]. In the nervous system learning materials, action potentials on the plasma membrane of cells are described [26]. Action potentials can be related to the concept of electricity in living things, such as human. Electrical phenomena based on scientific explanations can be applied to living things, both animals and humans. Preliminary study was carried out for the prospective Biology teachers on the topic of science explanation skills in the application of electricity in living things.

2. RESEARCH METHOD

The preliminary study uses a quantitative approach to 15 prospective biology teachers in semester VIII at one of the universities in Bandung. Samples were taken purposively. The main instrument is an essay of three questions regarding the application of electricity in living things (humans and animals). Examples of the application of electricity in living things are the form of action potentials in nerve cells and Peters's elephantnose fish. Indicator of scientific explanation questions are based on the components of Premise (P), Reasoning (R), Outcome (O), and Visual Representation (VR). Premise: a principle or fact as the basis for an explanation. Reasoning: the sequence of implications that follow the premise (constructing causes). Outcomes: scientific phenomena described. Visual representations can be in the form of pictures, diagrams, photos, graphs, symbols, tables, maps, and formulas [27]. The supporting instrument used is field notes. the data was analyzed using descriptive statistics, namely the mean answer score [28]. Examples of rubrics and scoring answers are presented in Table 1. The mean result is then made to certain criteria (Table 2).

TABLE 1: Rubric and scoring for answers to scientific explanation questions on electrical applications in living things.

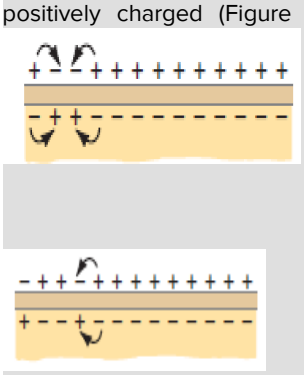
Question	Answer	PRO Component	Rubric & Scoring
Electricity in the human body can be found in the nervous system. There are two mechanisms of transmission of nerve impulses, namely through electrical and chemical synapses. Explain the mechanism of transmission of nerve impulses through electrical synapses!	Electrical synapse is a communication system in the human body between nerve cells through the movement of electric charges. When there is a stimulus that hits a point, the nature of the cell at that point changes to become more permeable, causing positive charges that were originally located on the outside of the cell to scatter into the cell so that the inner surface of the cell becomes positively charged (Figure ??).  **Figure ??.** Propagation of Action Potential Along the Axon	**Premise (P):** The nervous system provides ... (the communication facility within the body) Electrical synapses are ... (communication systems) in the human body between nerve cells with one another through (movement of electric charges).). **Reasoning (R):** When there is a stimulus that hits a point then: 1. The nature of the cell at that point changes to become more ... (permeable) 2. Positive charges that were originally located in .... (outer part of the cell), are able to scatter to ... (inside the cell) so that the ... (inside) surface of cell becomes ... (positively) charged. 3. The ... (difference of potential with positive value) is the cause of the occurrence of ... (work potential/action potential). **Outcome (O):** The work potential then ... (propagates) along ... (axon) to convey information to the brain in the form of ... (electrical flow) **Visual Representation (VR):** Figure ?? and 2	4: meeting the four criteria for correct answers (PRO-VR) 3: meeting the three criteria for correct answer 2: meeting the two correct answer criteria 1: meeting the one correct answer criteria 0: wrong answer / no answer

TABLE 2: Achievement criteria on the project report.

Achievement Percentage	Criteria
86%-100%	Excellent
76%-85%	Good
60%-75%	Sufficient
55%-59%	Fair
≤ 54%	Poor

(Source: [29])

3. RESULTS AND DISCUSSION

The scientific explanation skill of the prospective biology teachers, regarding the application of electricity in living things, are generally in the low criteria. The best criteria, based on the components, are in the component of premise, while the bad components are in reasoning and visual representation (Table 3).

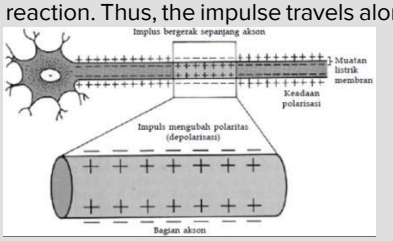
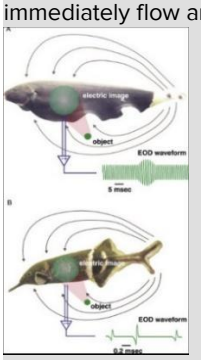
Table 3: Percentage and criteria for mean correct answers for the prospective biology teachers.

Answer	Question	P	R	O	VR
Correct (%)	1	86.67	26.67	46.67	6.67
	2	100.00	53.33	66.67	66.67
	3	93.33	26.67	93.33	0.00
Component Mean (%)		93.33	35.56	68.89	24.44
Component Criteria		Excellent	Poor	Sufficient	Poor
Mean Total (%)		55.56			
Total Criteria		Fair			

The best component is in the premise, which means that the prospective teachers are able to present facts and principles as the basis for scientific explanations. However, they have difficulty in providing reasoning and presenting the visual representation. Based on field notes, especially in question number one, only one person (6.67%) correctly included the image of the action potential on the plasma membrane of the nerve cell, and 14 people or 93.33% incorrectly included the image of a chemical synapse. Question number three regarding the application of electricity to animals, namely Peter's elephantnose fish, shows that none of the prospective teachers answered correctly based on the rubric and answer score. They included a picture of a visual representation of the Peter's elephantnose fish but excludes the description of the picture. Meanwhile, three people (20%) said electric eel, thus the answer was wrong. The new prospective teachers attained the skill of representing again. This is in line with research by [30] that not all modes of visual representation are referred to in the body of writing [31]. Visual representation can build scientific explanation and scientific literacy [3, 9]. This becomes a real challenge in visual representation to use various language symbols and special characteristics [32]. The completeness of visual information on their answers is important to include. Visualization facilitates understanding of the subject matter, reduces cognitive load so that the prospective teachers can streamline cognitive resources while maximizing memory resources, and support metacognition [23, 33, 34]. Examples of the prospective biology teachers' answers are presented in Table 4.

The skill of the prospective biology teachers is still in the components of facts and principles, which are still based on theory (knowledge). The results are in line with the research of [35] that states that junior high school students have the ability to explain content knowledge on the static electricity content. Therefore, a new prospective biology teacher can also have the skills to explain the facts and principles of electricity in living things. In the reasoning component, the criteria are poor. Reasoning is a logical

Table 4: Example of the answer from a prospective biology teacher to a question regarding electrical applications in living things.

Question	PRO Analysis on the Answers by the Prospective Biology Teachers
Electricity in the human body can be found in the nervous system. There are two mechanisms of transmission of nerve impulses, namely through electrical and chemical synapses. Explain the mechanism of transmission of nerve impulses through electrical synapses!	Premise: The nervous system sends very small electrical signals back and forth, carrying information from one part of the body to another. Reasoning: The outer membrane of the nerve cell is positively charged due to an excess of Na+ atomic cations. The inner membrane of the nerve cell is negatively charged because many K+ ions leave the axon. This state is called polarization. Outcome: Then a polarization reversal process occurs which is repeated to cause a chain reaction. Thus, the impulse travels along the axon. Visual Representation: 
Peter's elephantnose fish is one of the animals that can generate electricity. The name of the organ that can generate electricity in these animals is the electroplax cell which is located in the tail. Explain how Peter's elephantnose fish can produce high voltage electricity?	Premise: The Peter's Elephantnose fish is equipped with a special electrical generating organ, located in the tail, which is made up of thousands of "box-like multi-nucleated cells" called electroplaxes (or electroplaques). Reasoning: Each electroplax cell has a negative charge on the inside and a positive charge on the outside. Outcome: When the organ is stimulated through muscle contraction, it will create a high electric current. Thus, elephantnose fish are able to detect varying degrees of distortion and can then distinguish between predators and prey. Visual Representation: 
The Peter's elephantnosed fish uses the electric current it produces to attack enemies or hunt prey. Explain how does the mechanism work?	Premise: An electric current will be released when the fish's muscles contract, at that time the fish are able to detect the presence of predators and prey. Reasoning: Electric currents in Peter's elephantnose fishes are generated by electrocytic cells or electroplax in the muscles in the tail of the fish. Outcome: So, when this electroplax cell is stimulated, for example through touch by a predator or predator, an electric current will immediately flow and sting anyone who touches it. Visual Representation: 

sequence that follows a premise. New prospective biology teacher can understand the principle or concept, but the scientific explanation cannot be understood properly [22].

The overall results of scientific explanations with low criteria indicate that the prospective biology teachers have not been able to integrate knowledge into daily life applications. This becomes a challenge for educators, in this case lecturers, to provide

practical appropriate steps in teaching science that is integrated with the life of the prospective biology teacher [2]. Scientific explanation is one of the goals of science education and part of scientific literacy [1]. Therefore, educators play an important role in providing direction to students to improve their scientific explanations that are integrated with everyday life [14, 16]. Scientific explanation can provide avenues for students to improve their understanding of scientific phenomena [36]. Therefore, prospective biology teachers should build scientific explanations for students in the future so that students have reasoning skills that are in accordance with world developments and the goals of science education [1, 14].

4. CONCLUSION

The criteria for science explanation skills of the prospective biology teachers are still low, especially in the components of reasoning and visual representation. The highest achievement is in the premise of presenting facts and knowledge. Therefore, appropriate learning strategies are needed to improve the science explanation skills of the prospective Biology teachers to improve scientific literacy as part of the goals of science education.

Acknowledgments

Gratitude is expressed to the Institute for Research and Community Service, State Islamic University of Sunan Gunung Djati, Bandung, which has provided funding for this preliminary study.

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