Perceptions of Prospective Biology Teachers on Scientific Argumentation in Microbiology Inquiry Lab Activities

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Abstract. Inquiry laboratory activity and scientific argumentation in science education should be promoted and explicitly experienced by prospective biology teacher students in classes, including in microbiology courses. The goal of this study is to get information about perceptions of prospective biology teachers on scientific argumentation in microbiology inquiry lab activities. This study reported the result of a survey research to prospective biology teachers about how their perception about microbiology lab classes and their perception about inquiry and argumentation in microbiology lab activities should be. The participants of this study were 100 students of biology education department from an institute in Cirebon, West Java taking microbiology lecture during the fifth semester. The data were collected using questionnaire to explore the perceptions and knowledge of prospective biology teachers about microbiology, inquiry lab activities and argumentation. The result showed that students thought that the difficulties of microbiology as a subject were the lack of references and the way lecturer teaching. The students’ perception was that argumentation and inquiry should be implemented in microbiology courses and lab activities. Based on the data from questionnaire, It showed that prospective biology teacher students had very little knowledge about scientific argumentation and its implementation in science education. When the participants made arguments based on the problems given, they showed low quality of arguments.

1. Introduction

Microbiology is regarded as the basic science of biology, because microbes are ideal systems in investigating basic questions in Biology, such as the question of sex origins, specialization, adaptation, cellular function, genetics, biochemistry, and the physical properties of all other living organisms [1]. Besides, microbes also determine the quality of human and other living organisms’ life, such as in the fields of health, industry, ecology, biotechnology and genetically engineering. Microbes have important roles in the future, because the technology has more and more attractions in developing new techniques investigating the utilization of microbes to produce food, to overcome environmental damage, to cure diseases and even to create biological weapons [2]. Microbiology is one of the compulsory courses that should be taken by students majoring in biology education as prospective biology teachers.

Learning microbiology as science for prospective biology teacher is not only learning theory in lectures but also learning to experience experimentation skills through laboratory activities.
Therefore, lab activity is an essential activity and an integral part of microbiology learning. Lab activities are activities that involve students in observation, manipulation of objects and real material. They interact with materials and equipment in order to understand how the universe works so that they are able to link between the domain of knowledge and thinking skills with the real life [3]. Microbiology laboratory activities in this study provide students with basic skills to isolate microbes from their sources, to grow microbes in the medium, to examine the presence of microbes in some environments, to examine antimicrobial substances and to examine the role of microbes in some fields.

Science learning through inquiry activities, including microbiology lab activities that integrate hands-on and minds-on activities, is in accordance with science education objectives according to National Science Education Standards [4]. It is to create well-educated students who are able to experiment properly and have the urge to find out and understand the universe, using scientific processes and appropriate principles in making decisions.

Argumentation is one of important skills that should be taught in science education. Argumentation is defined as the connection between claims and data through justification and evaluation of knowledge [5]. The term argumentation is not always referred to debates, although it is one of many ways of argumentation. Argumentation is a process of thinking and social interaction where students can construct and criticize arguments [6]. In the other hand, argument is defined as a series of proposition. Students’ involvement in scientific argumentations can lead to a better understanding of the concepts and the processes of science [5].

Kuhn [7] argues that argumentation and inquiry skills are two important skills in science learning that need to be possessed by prospective science teacher students. Prospective science teacher students who have the opportunity to design inquiry-oriented laboratory activities that are enriched with critical discussion, have the opportunity to support argumentation, so they can be encouraged to promote argumentation in their classroom when they teach [8]. In order for argumentation to take place in the classroom in science learning, students must play an active role in the discussions [9]. Unfortunately, science learning has so far been conducted with an emphasis on question and answer interaction and teacher-dominated lab activities that does not involve students in activities that support discussion, argumentation or social construction of knowledge [10]. Students' opportunities to participate in authentic arguments in science classes are still very rare.

Students’ perceptions of science affect their learning and achievements in learning science [11]. Research shows that there is a relationship between students' attitudes toward science learning in school with their learning and achievement in learning science [12]. Research on the perception of prospective biology teacher students on arguments in lectures and microbiology lab activities can be useful for understanding students' difficulties in applying arguments in science classes. There is limited understanding of how prospective science teacher students’ perceptions on argumentative discourse in scientific argumentation, their knowledge and ability to participate in a scientific arguments. Therefore, the main purpose of this study is to investigate perceptions of prospective biology teachers on scientific argumentation in microbiology inquiry lab activities.

2. Method

This field study research was conducted in one of the Education Institute for Educational Staff (LPTK) in Cirebon West Java. This study was conducted by involving 100 students as respondents who are in the 5th semester taking the course of microbiology. The students’ age varied from twenty to twenty three.

Respondents were asked to provide information using a set of questionnaire accordance with their knowledge and views on the course of microbiology, particularly on lectures and laboratory activities as well as their knowledge and abilities of scientific argumentation. The questionnaire consisted of 5 parts based on the group of question asked. The first part was about microbiology course, while the second part was about microbiology lab activities in general. The third part included questions in perceptions about inquiry and argumentation in microbiology courses and lab activities. The forth part was the questions about students’ knowledge on scientific argumentation and the last part was the......
questions to test the students’ skills of scientific argumentation used to give opinions and arguments to some microbiological problems.

This field study research used descriptive qualitative approach. Data obtained through a set of questionnaire. Questionnaires are used to obtain student background data, students' perceptions of lectures and microbiology practice, and to determine the level of knowledge and ability of students about scientific argumentation. The questionnaire data was analyzed descriptively as a description of what happened in the field. While the results of the level of scientific argumentation were analyzed by the modified Toulmin's Argumentation Pattern (TAP) Scheme, by Toulmin (1958) [13].

3. Result and Discussion

3.1. Students perception about microbiology as a course

The prospective biology teacher students in this study did not think that microbiology is the most difficult course. They believed that statistics was the most difficult (96%) subject in this semester followed by genetics and biochemistry, no one of the students answered microbiology as the most difficult course. While, microbiology included courses with moderate difficulty (79%). According to the students, they did not regard microbiology as a difficult course on the grounds that despite using scientific terms, the discussion is related to daily life. So, for them it was more triggering curiosity, easier to remember and easier to be learned.

Factors that determined the difficulty in studying microbiology was the lack of reference books (52%) and the course material itself (32%). Students realized the importance of reference books to study the courses, so they find it difficult to learn course material if reference books are not available. While, 40% of students considered that the way lecturers teach was enough to affect the degree of difficulty of microbiology courses.

Then students were asked to choose the subjects considered to be the most difficult in the course of microbiology. Most of them (80%) answered microbial genetics, followed by microbial nutrition and metabolism (7%) and microbial classification (7%). While the cause of the difficulty of the subject matter was that it was a matter of process (45%) and scientific terms used (36%). As many as 57% of students are interested in studying further microbiology and 24% of them were very interested.

3.2. Students perception about laboratory deactivities in microbiology

The students' perception about the most important benefit of lab activities in microbiology was to learn investigation and research (49%) and to help them understand the concept (33%) followed by develop scientific attitudes (14%). Almost all of the students (97%) also assumed that lab activities can help them understand the microbiological concepts being studied. As a prospective science teacher, students understood very well the benefits and importance of lab activities in science learning, including in learning microbiology. As revealed by Millar [3], that laboratory practice is an integral activity in learning science and is a process of learning through experience. Lab activities aim to motivate students, develop experimental techniques and skills, learn scientific approaches and enhance theoretical understanding of subjects.

The most difficult laboratory activities were isolation and transfer of microbes (57%), followed by antimicrobial effectiveness test (22%) and microbial dyeing technique (15%). While the cause of the difficulty is due to the complexity of the method (63%) and the unsuspecting participant condition (17%). In composing the lab report, Students thought the most difficult part was in writing the discussion (80%) and followed by determining the tools, materials and methods (7%). While the main source of reference in the discussion is from the internet in the form of blogs and articles (74%) followed by reference books (14%).
3.3. Students perception on inquiry and argumentation in microbiology courses and lab activities

Table 1 shows the result of prospective biology teacher student’s perception on inquiry and argumentation in microbiology courses and lab activities.

| QUESTION                                                                 | YES | NO |
|-------------------------------------------------------------------------|-----|----|
| Is microbiology lab activity already oriented inquiry?                  | 68  | 32 |
| Should microbiology lab activities be inquiry-oriented?                 | 94  | 6  |
| Is there a discussion session and argumentation in a microbiology lecture? | 81  | 19 |
| Is it necessary to have discussion sessions and arguments in microbiology lectures? | 95  | 5  |
| Is there a discussion session and argumentation in a microbiology lab activities? | 84  | 16 |
| Is it necessary for discussion and argumentation sessions in microbiology lab activities? | 90  | 10 |

Based on the questionnaire result as shown on table 1, students considered that the lab activities conducted in microbiology courses had been inquiry oriented (89%) and microbiology lab activities need to be inquiry oriented (94%). Although lab activities that have been done by students in the research site were considered to be inquiry-oriented, but it still dominated by low level inquiry, such as discovery learning, interactive demonstration or inquiry lesson, and actually the lab activities done have not fully applied inquiry lab [14]. The activities were mostly still being guided by the manual books.

As many as 81% of students considered there were discussion sessions and arguments in the lecture of microbiology while in practice as much as 84%. They also argue that there should be more discussion sessions and arguments in lectures (95%) and in lab activities (90%). According to students so far, more discussion activities conducted in lectures than lab activities. However, during the lab activities, the instructor always actively provided questions related to step by step and the reason for a method in the experiment. Therefore, students assumed that there are already discussion sessions and arguments in lectures and lab activities.

3.4. Student knowledge about scientific argumentation

Table 2 shows the result of the forth part questions in the questionnaire asked about Student knowledge about scientific argumentation.

| Question                                         | True | Half | False |
|--------------------------------------------------|------|------|-------|
| Understanding on the term of scientific argumentation | 28   | 42   | 40    |
| The importance of argumentation in science learning | 12   | 36   | 52    |
| Parts of an argument                             | 0    | 22   | 78    |

Data about students' knowledge of the argument showed on table 2, that most students did not know much about scientific argumentation in science learning. Students did not know much about the meaning of scientific argumentation, the importance of scientific argument in science learning and components in argumentation. But, some students had better answer when describing their perception on scientific argumentation, although they had never specifically studied about argumentation. Students emphasized the need for evidence in expressing scientific opinion. But they had not paid any attention to the word or phrase linking the claim or opinion with the evidence presented.
3.5. Students’ ability to make arguments

Table 3 shows the result of the questions that indicate students’ ability to provide arguments.

| No. | Topics of problem         | Level 1 | Level 2 | Level 3 | Level 4 |
|-----|---------------------------|---------|---------|---------|---------|
| 1.  | Antibiotics               | 63      | 37      | 0       | 0       |
| 2.  | Sterilization             | 46      | 54      | 0       | 0       |
| 3.  | Tempe Fermentation        | 34      | 54      | 12      | 0       |

While the ability of students in drawing arguments for a problem, as shown on table 3, was still relatively low, by looking at the answers to the questions solely on most of claims without data supported or accompanied by simple data. Even the claims given were not all valid.

4. Conclusion

Based on the results of the study, it can be concluded that the prospective biology teacher considered the course of microbiology as a course with medium difficulty level. The difficulties faced by students are the lack of reference books and microbial genetics topics as the most difficult subject. Students understand the importance of lab activities in microbiology and the need for inquiry-oriented lab activities and scientific arguments. Students had low knowledge and argumentation skills.

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