The ability of scientific reasoning of students with drawing based modeling

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Abstract. This study aims to determine students scientific reasoning using Student Activity Sheet based on Drawing-based Modeling approach in Biology Education Study Program of Muhammadiyah University of Bengkulu. This study included the type of experimental research. The research design used is Research and Development (R&D) design with 4D model (define, design, develop, disseminate). The subjects of this study were 31 students of Biology Education University Muhammadiyah of Bengkulu. The data collection of scientific reasoning skill is taken by giving multiple choice questions before and after learning and assessed by the rubric of scientific reasoning. Analysis of scientific reasoning data using Anatest version 4.0.9. The results showed the percentage of student’s achievement in each category of reasoning, low, moderate, high. It is generally seen that students reasoning ability is in high category, that is 78% of students get high score. The lowest percentage of students reasoning ability achievement is found in justification reasoning that is 22%, while the percentage of students achievement reasoning achievement is the highest in reasoning synthesis, as much as 78%. The results of this study provide a conclusion that the Student Activity Sheet based on Drawing-based Modeling can improve student’s scientific reasoning ability.

1. Introduction

The process of teaching and learning activities that occur in the environment of college or school is optimal and meaningful is not easy and many factors that influence it. One of the factors that can support the process of learning activities is optimal and meaningful is the availability of teaching materials or learning resources are adequate and very important and get special attention. Teaching materials are an important role in teaching and learning activities in class, and even now has become the main teaching instrument [1]. Teaching materials that want to be developed is printed material form Student Activity Sheet. Student Activity Sheet to be developed must be in accordance with the demands of the curriculum and able to support the activities, motivation, learning outcomes and students 'scientific thinking skills, especially students' scientific reasoning abilities.

Cell Biology is a teaching material whose material or subject matter is abstract and difficult to understand. Subjects such as cell structure and organelle, cell membrane, cell division, cell metabolism, substance transport and cell abnormality are abstract and elusive. The data of preliminary study that
have been done in Biology Education Study Program University Muhammadiyah of Bengkulu (2016) revealed some weaknesses of cell Biology learning so far, namely: (a) current practicum activity has not been effective and inefficient, because in general practicum is considered only as a complement (b) less optimal laboratory activities, more time consuming students, (c) learning Cell Biology is generally limited to differentiating the structure and organelle of cells between a group of cells with a cell group others, (d) the learning process has not been able to elicit the phenomenon, (e) the ability of scientific reasoning skill is low and tends to not exist at all. Students often consider the material abstract so that they have difficulty understanding the concept of phenomena, interconnections, and cellular mechanisms in tissues [2]. There are still many students who are not able to understand the material contained in the learning of Cell Biology [3]. In the discussion, understanding, mastery, why and how processes that occur in Cell Biology is required the ability of thinking processes, including scientific reasoning skills.

The importance of scientific reasoning skill has been expressed by some researchers who say that scientific reasoning is one of the most important thinking skills in science, technology, engineering, and mathematics [4]. Scientific reasoning habits are important in everyday life because the reasoning plays a role in making correct and logical decisions on controversial issues [5]. Socio-scientific issues are issues based on a scientific problem or concept, controversial, discussed in the public sphere and usually have political and social influence [6].

In an effort to increase the activity of learning process and to stimulate students' thinking ability in Cell Biology course, an alternative solution is chosen to develop teaching materials. Teaching materials that want to be developed is a printed material in the form of Student Activity Sheet based on Drawing Based Modeling. Teaching materials have a very important role in the education system. Teaching materials in various forms, both print and not print are important in achieving educational goals [7]. The role of teaching materials in the educational process occupies a very strategic position and also determine the achievement of educational goals [8]. In the process of teaching and learning in the classroom in addition to involving students in learning and using models, strategies, learning approaches should be educators can also choose and use appropriate learning media. In poor schools or campuses in terms of infrastructure, image-assisted media and modeling of computer applications is the most appropriate medium for use in classroom learning.

In support of students thinking ability especially scientific reasoning ability in Cell Biology course, chosen approach of Drawing Based Modeling. Drawing Based Modeling in accordance with the demands of the curriculum and able to support the thinking process especially the students scientific reasoning abilities. Drawing Based Modeling, this approach is more effective in achieving conceptual and operational understanding that can stimulate scientific reasoning skills rather than other learning approaches [9]. Modeling can also provide an opportunity for students to think and discuss in a scientific way about student ideas [10].

The description of the above background is the basis of the researcher to know the extent to which the student activity sheet based on Drawing Based Modeling approach can improve students' scientific reasoning ability especially on cell Biology learning.

2. Method

2.1. Research methods

Research was conducted based on Research and Development (R & D) design with 4D model (define, design, develop, disseminate) [11]. In the define stage, a review of literature in the form of curriculum, syllabus and Semester Lecture Plan Cell Biology course and peer interview. In the design stage, the student activity sheet design is done. At the develop stage develops the activity sheet of Cell Biology students based on Drawing Based Modeling. In the fourth phase of the disseminate trial and implementation of student activities based on Drawing Based Modeling to stimulate the scientific reasoning skill. The subjects in this study are all Biology teacher candidates in the first semester who
are studying Cell Biology at Biology Education Study Program University Muhammadiyah of Bengkulu.

2.2. Data collection
Scientific reasoning skills data were taken by multiple choice questions before and after learning and viewing learning recordings and discussions on drawing-based modeling implementation using eBeam Capture computer applications and assessed by scientific reasoning scoring rubric [12].

2.3. Data analysis
Analysis of scientific reasoning ability is performed using Anatest version 4.0.9. This test consists of 25 items written test of multiple choice with 5 choices, consisting of six kinds of scientific reasoning, namely generativity, elaboration, justification, explanation, coherency logic, and synthesis. The results of students scientific reasoning tests are divided into three categories: low (score 0-40), moderate (score 41-70), and high (score 71-100) [12].

3. Result and discussion

3.1. Students scientific reasoning skill
The results is obtained by applying drawing based modelling in Cell Biology Course in Biology Education Department, University Muhammadiyah Bengkulu is as follows:

![Figure 1: Scientific reasoning skill.](image-url)

Figure 1 shows the number of students on each scientific reasoning indicator that scores high on the implementation of student activity sheets based on drawing based modeling approach of Cell Biology learning. It is generally seen that students' scientific reasoning ability has been categorized in high criterion that is the percentage of achievement as much as 78%. This is seen in the scores of every scientific reasoning indicator that is, on the generativity reasoning indicator as much as 93% of students get high criteria that is 19-24 score. Furthermore, in elaboration reasoning as much as 68% of students get high criteria that is score 13-18, justification reasoning as much as 56% of students get high criterion that is score 13-18, explanation reasoning as much as 67% student get high criterion that is score 13-18, coherency logic as many as 82% of students get very high criterion that is 19-24 score, synthesis reasoning as much as 99% student get very high criterion that is score 19-24. The results of this study
show that on the scientific reasoning of most student’s synthesis indicator, that is 99% with very high score 24. This is because the ability of students able to answer the test questions on the indicator synthesis correctly and provide a comprehensive reason and create images with description of the image completely. While the justification reasoning ability of the least students who scored high, i.e. only 56% got a score of 13-18. This is because students are not able to justify (provide evidence, inference, and experiment in answering questions and create drawings) that they make so that the answers do not form a systematic theory structure.

Based on the drawing product on student activity sheet based on drawing based modeling approach made by students to improve scientific reasoning ability in Cell Biology research which has been done can be seen in the following Figure 2.

![Display images of cell structures and organelles](image.png)

**Figure 2.** Product image on student activity sheet of Cell Biology material.

The data in Figure 2 shows that students are happy to learn with student activity sheet based on drawing based modeling because it can stimulate scientific reasoning ability and make it easier for students to understand abstract cell biology.

3.2. The value of students scientific reasoning abilities

The result of students' scientific reasoning ability using applying of drawing based modeling student strategy in Cell Biology can be seen in the following table 1.

| No. | Material                        | Minimum | Maximum | Mean±Deviation Standard |
|-----|--------------------------------|---------|---------|-------------------------|
| 1.  | Structure and cell organelle   | 17      | 100     | 77±2.43                 |
| 2.  | Plasma membrane                | 25      | 100     | 79±2.23                 |
| 3.  | Transportation of substances   | 33      | 91      | 83±1.62                 |
| 4.  | Cell division                  | 8       | 100     | 78±2.53                 |
| 5.  | Cell metabolism                | 8       | 100     | 77±2.69                 |
| 6.  | Cell abnormal                  | 25      | 91      | 77±1.97                 |

Based on the data in table 1 it can be stated that in general the students' scientific reasoning ability develops. This is seen from the maximum value above 90. However, judging from the minimum value for all the material scores below the average, with the value of 8 on cell division and cell metabolism, the value of 17 structural and organel cell materials, the value of 25 on the plasma membrane material and cell abnormalities, and the value of 33 in the substance transport material. To capture the data of students' reasoning abilities given the choice of multiple choice of 12 points of reason, the test is given
after the learning of each subject is completed. In addition to given the students are also required to present images made using beam capture application. The pictures presented are related to the reasoning abilities of each subject of Cell Biology. The value of the student’s scientific reasoning ability has been categorized high, it looks at the average standard deviation of 2.24. A statistical count on scientific reasoning ability shows that the average standard deviation obtained indicates that scientific reasoning ability using drawing based modeling approach in cell biology learning has been significant.

The ability of students scientific reasoning seems to have entered the category or high level, because in the process of learning, especially in group discussions have many students who work together. The reasoning skill is derived from the thinking process of individual reasoning and collaborative cognition through a problem-based learning model [13]. In addition, based on the analysis of journal articles that have been done, the reasoning ability can be improved through the application of several learning models such as inquiry [14], Problem Based Learning [15], ICT-based [16], play and group discussions [17]. In other research contexts, in addition to the application of learning models to enhancing reasoning abilities, it can also be the correlation of reasoning to conceptualization [18], achievement [19], logical thinking [20].

4. Conclusion

Based on the research that has been done, it can be concluded that Drawing-based Modeling can improve students scientific reasoning ability, this is seen from the percentage of students reasoning achievement of 78% who get high score (score > 70). The lowest scientific justification reasoning ability has a 30% percentage of achievement, while the highest scientific synthesis reasoning ability has 70% achievement percentage.

Acknowledgments

That is all that the author can convey the material that has been discussed in this article. Acknowledgments to all those who have assisted in conducting this research. I want to say thank you for my Lecturer Dr. rer. Nat. Adi Rahmat, Prof. Hj. Dr. Sri Redjeki, M.Pd and Dr. Taufik Rahman, M.Pd for guidance and advice so that I can finish this dissertation. The authors also thanked to the Directorate General of Higher Education who has funded this preliminary study.

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