Analyzing scientific reasoning skills of biology prospective teachers

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Abstract. This research aims to obtaining students' scientific reasoning skills in plant anatomy classes. The participant was the biology education student that take plant anatomy course (n=139) at a university in Sumatera, Indonesia, were participated in this study. Data of scientific reasoning skills were collected using instrument CTSR test. The data were processed by calculating score for each indicator. The scores of Scientific Reasoning Skills (SRS) is 0 to 12 which divided in 3 categories: (1) concrete; (2) transitional and (3) formal reasoning. Results of this research show that students' scientific reasoning skills in Biology education student are: 52.5% students have a concrete; 32.4% a transition and 15.1% at formal reasoning. Based on data of this study, it is suggested that students' scientific reasoning skills at formal levels was very low. To increase scientific reasoning skills of the students, it is needed revision on instructional strategies for plant anatomy course.

1. Introduction

The purposes in education of science are to prepare the students to think critically, solved the science problems and develop students' scientific reasoning. Scientific abilities is very important to support one's success in solving scientific problems in everyday life and developing one's future careers [1]. The ability to solve scientific problems based on data is a vital skill in the modern world. In addition, The students must have knowledge about processes and concepts of science in order to succeed in various fields, especially industry [2]. Reform in science education need the learning process that solved the science problems, achievement concepts and make interconnected of science with everyday life. For this purpose, reasoning ability are needed for each student.

Reasoning ability is one of the abilities that are expected to be trained in biology education students. It is to prepare students to be succeed in solving the problems of learning of science, especially in learning of Biology. Students must able to support conclusions structured reasoning and evidence. Reasoning is a central and important thinking skill in Biology, especially in plant anatomy learning. Plant anatomy learning need the students to understand about concepts of structure of cell, tissues and its function. The structure of plant anatomy (cells, tissues and organs) of plant that are three-dimensions (3D) structure [15].In addition, plant anatomy learning also required the students to understand the structure of plant tissues in two-dimensions (2D) and three-dimensions (3D)[15].The topics in plant anatomy were the anatomical of the cell, dermal tissue, ground tissue, secretory tissue, vascular tissue and the order organs of plants [15].

Reasoning ability is general concept that refers to the process of thinking to draw conclusions as new statements or inferences from information and it can be expressed in words or others symbols [17].This means that reasoning is a specific way of thinking in drawing conclusions from several existing premises.Reasoning is a thinking activity that is carried out conciously, systematically, directed and aims to produce valid conclusions. The reasoning ability is not an ability that a person bring from birth, but is strongly influenced by the development of reasoning abilities that are influenced by environmental factors. One of them is scientific reasoning.

Scientific reasoning is related to inductive and deductive reasoning abilities and this is related to a process in producing scientific knowledge and reasoning based on data [3]. Scientific reasoning is a strategy that used to process information to obtain a conclusion. This processes are related to the abilities of cognitive such as reasoning abilities and critical thinking skills [3]. Reasoning of scientific involves the ability of the students to construct the arguments [4]. Therefore, scientific reasoning is a skill that are very expectedly to be trained in science classes learning. This is an effort to prepare students to succeed in the 21st century. To accommodate this, curriculum development should be focused on problem solving, reasoning, conceptualization, and analysis.

Scientific reasoning, allows students to develop their thinking abilities by using various sources of problems presented to develop higher-order thinking skills [1 There are many factors involved in advancing scientific reasoning, namely: (i) generating expectations, (ii) variables of control, (iii) producing causes, (iv) determining probabilistic reasoning, and (v) determining proportional reasoning [5]. The scientific reasoning test developed by [6] has three groups: concrete, transitional, and formal reasoning. There are four that involved in concreate reasoning level: class inclusion, conservation, serial ordering, and reversibility. Formal level was theoretical, combinatorial, functionality and proportional, control variables, probabilistic and correlational reasoning [5, 6].

The previous study about reasoning and scientific reasoning have shown that the students with high scientific reasoning get an impact on students' academic achievement [7]. Beside that learning with inquiry approaches enhances students' reasoning abilities[8]. In a similar by [9] argued that teaching with an inquiry approach has the potential to encourage students to reason scientifically. Beside that the previous research also indicated there are positive correlation between academic achievement and scientific reasoning [10]. Students with the higher reasoning were better able to solve the problems of the test [8]. It's concluded that the students with higher score in LCTSR, have higher score to in achievement exams. Based on these informations, it is absolutely necessary to investigation about the students' scientific reasoning in plant anatomy course.

So, the focuses in this paper is discussion about student' scientific reasoning in plant anatomy course. Students' scientific reasoning focuses in three categories: concrete, transition and formal reasoning. The aim of this research was to get the information about the category of student scientific reasoning and prepare the students to teach on the school later. To accommodate this, it is necessary to develop the strategy that improve student reasoning, especially reasoning in plant anatomy learning. The results of this study are used as a reflection and as a basis data in developing anatomy course.

2. Methods

2.1. Participants

This research was used a descriptive method. There are 139 (7 males and 132 females) biology education students at a university in Indonesia was participated in the study. The participant was the student in third semester (18-22 years old) who will participate in the plant anatomy learning.

2.2. Instrument Test and Procedure

The present study shows that LCTSR was used as instruments to measure and interpretation of scientific reasoning of the student [6]. LCTSR test is a reasoned multiple choice test that consisting of 12 items. Each item has a answers and reasons why choosing it. Each question has a score of 1 if the

student give the answer and its reason correctly. If the answer or its reason is wrong, or both are wrong then the score is 0. A maximum score of 12 is obtained if all items are answered correctly and the reason chosen is correct. Scientific reasoning heve the range of scores level (0-12) which categorized by Lawson into three levels: Concrete (score: 0-4); Transitional (Score:5-8); and Formal (Score:9-12) [5, 6]. The data were processed by calculating the score for each item of indicator. The data obtained are then analyzed descriptively.

3. Result and Discussion

This research aims to get the information about students' scientific reasoning in in plant anatomy course. The results of this study indicated that scientific reasoning skills of students in plant anatomy classes are: 52.5% students have a concrete; 32.4% at transition and 15.1% at formal reasoning (Table 1).The data on the Table 1 show that students' scientific reasoning skill is still dominant at the concreate level. According Tables 1, indicates that the higher percentage of student scientific reasoning was concrete level and the lowest percentage was formal reasoning level.

Table 1. Student Scientific Reasoning

Reasoning	N	Persentage (%)
Concreate	73	52.5
Transitional	45	32.4
Formal	21	15.1
Total	139	100

Analysis of student reasoning shows that in general student reasoning is at a concrete and transitional level. There are 73 students in concrete level. The student at this level have a score between 1 and 4. If viewed in terms of age, students of biological education have an age range of 18-22 years. This result is contrary to the development theory presented by Piaget which states that an 11-year-old child has a developmental stage at a formal level [11]. This is characterized by a number of skills possessed namely variable identification and control skills, probabilistic thinking skills, correlational thinking skills, hypothetical-deductive thinking and reasoning skills, comminatory, functional and proportional reasoning skills, and correlational reasoning skills [12]. This result can be used as a feedback that the anatomy learning has not been able to repaired the scientific reasoning of students.

Analysis of the result indicates that majority of the student with low achievement in plant anatomy reasoning have SRS in concreate level. In this study found that students with formal reasoning performed better on solved plant anatomy problems. This was indicated that needs to improve of SRS in Biology student. This is relevant with the previous study that scientific reasoning of the student can be trained, developed and transferred [1, 13, and 14]. A person's reasoning ability will develop with many factors that influence it [15, 16]. One that can improve students' reasoning abilities is the use of appropriate learning methods. This result shows that the previous learning both at the middle level and in the early semester has not practiced reasoning for students. According to this result, needs to repair the strategy in plant anatomy learning to improve student reasoning. The instructional strategies of plant anatomy learning must develop based on complex problems in order to improve students reasoning in transitional and formal level.

4. Conclusions

This study provides information that most of students (52.5%) have a level of concrete reasoning and the others (32.4%) were transitional and formal (15.1%) levels. According to this result, needs to repair the strategy in plant anatomy learning to improve students reasoning. The instructional

strategies of plant anatomy learning must be develop based on complex problems and it's can prepare the student to think spatially, critically, and creatively in plant anatomy concepts.

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References

[1] Bao L, Cai T, Koening K, Fang K, Han J, Wang, J, … Nianle W 2009 *Education Forum* **232** 586-587
[2] Myers B E & Dyer J E 2006 *Journal of Ugricultural Education* **47(4)** 52-
[3] Thoron C A & Myers E B 2012 *Journal of Agricultural Education* **53(4)** 156-170
[4] Hand B M, Prain V & Yore L 2001 Sequential writing tasks influence on science learning. In P. Tynjala, L. Mason & K. Lonka (Eds.). *Writing as a Learning Tool* (pp. 105–129). Boston, MA: Kluwer Academic Press
[5] Lawson A E 1982 *Journal of Research in Science Teaching,* **19(9)**743–760
[6] Lawson A E 2000 *Classroom test of scientific reasoning (revised)*. Retrieved 11 Agustus 2017, from http://www.ncsu.edu/per/TestInfo.html
[7] Cramer K T Post 1993 *Mathematics Teacher* **86(5**) 404-407
[8] Lawson A E, Alkhoury S, Benford R, Clark B R, & Falconer K A 2000 *Journal of Research in Science Teaching,* **37(9)** 996–1018
[9] Dolan E & Grady J 2009 *Journal Science Teacher Education* **21** 31-55
[10] Schen M S 2007 *Scientific reasoning skills development in the introductory biology courses for undergraduates* (Unpublished doctoral dissertation). The Ohio State University, Columbus, OH
[11] Piaget J 1964 *Journal of Research in Sciences Teaching* **2** 176-186
[12] Karplus R 1977 *Journal of Research in Science Teaching* **14(2)** 169-175
[13] Bloom B S 1956 *Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain* (David McKay, New York)
[14] Adey P M Shayer 1994 *Really Raising Standards: Cognitive Intervention and Academic Achievement* (Routledge, London, 1994).
[15] Ermayanti, Rustaman N Y & Rahmat A 2017 *IOP Conf. Series Journal of Physics Conf. Series* **812** 1-8
[16] Ermayanti, Rustaman N Y & Rahmat A 2017 *Proc. Intern. conf., The Asian Education Symposium (AES), Ideas for 21st Century Education Taylor & Francis Group, London, ISBN 978-1-138-05343-4*
[17] Lohmn D F & Lakin J M 2009 *Handbook of Intelligence* (2nd ed.) New York: Cambridge University Press