

Students' Scientific Reasoning At SMA Adabiah Padang

Indah Pratiwi¹, Heffi Alberida^{2*}

¹ Program of Biology Education, Faculty of Mathematics and Sciences, Universitas Negeri Padang

Jl. Prof. Dr. Hamka Air Tawar Barat Padang - 25131, Indonesia

²Lecturer of Biology Department, Faculty of Mathematics and Sciences,

Universitas Negeri Padang

Jl. Prof. Dr. Hamka Air Tawar Barat Padang – 25131, Indonesia



Abstract – Scientific reasoning is one of the higher order thinking skills that are systematic and logical by using the scientific method in solving problems. Scientific reasoning skills are crucial to build students' understanding of the main concepts followed by the ability to communicate them to others. Moreover, it also has a long-term impact on students' academic achievement. The aim of this study was to identify students' scientific reasoning in order that it affects the development of scientific reasoning abilities as a learning paradigm in 21st century, especially in the learning process of biology. The final results of this study are expected to be the foundation for empowering students' scientific reasoning abilities. This study used a test of scientific reasoning ability on virus material utilizing instrument adapted from Lawson (1978). The test consisted of 12 essay questions with 8 content questions and 4 reasoned questions. This research is a descriptive study conducted on students from class X MIPA 2 and X MIPA 3 at SMA Adabiah Padang. The results showed that the scientific reasoning abilities of students in both classes were mostly in the low and medium criteria, in other words, none of the students from the two classes had high scientific reasoning ability. In conclusion, many students have low scientific reasoning skills. The students from X MIPA 2 and X MIPA 3 had the lowest scientific reasoning ability on analysis and argumentation. On the other hand, the best reasoning skill in both classes was found in the indicator of knowledge.

Keywords – Scientific Reasoning Ability.

I. INTRODUCTION

In today's world, which is the 21st century, globalization and openness has become a fundamental part that changed the order of human life fundamentally (Wijaya, 2016). To implement the competence in the 21st century, schools not only focus on mastering the main subjects but also aim in improving academic abilities at higher levels. It is important for students to develop competency in 21st century learning outcomes through various types of reasoning according to situations and conditions (Tapilouw, 2015).

Reasoning is the process of drawing conclusions from evidence and facts by connecting existing knowledge to make new conclusions. This reasoning ability is a directed logical thinking process that is connected by reviewing the problem in its own in order to make conclusions based on the evidence that is owned (Lee, 2010). Scientific reasoning is an indispensable skill. Students need to develop important competencies of 21st century learning outcomes through empowering scientific reasoning. The scientific

reasoning abilities of students can be improved by utilizing an appropriate learning model who are expected to prepare for the challenges of the 21st century.

Scientific reasoning ability is a systematic and logical high-level thinking ability using scientific methods in solving problems (Koenig, 2012). Scientific reasoning is very important to be trained due to its function as the basis of the process of discovering and developing other skills such as higher order thinking skills and problem solving (Purwana. U, 2016).

Scientific reasoning skills are critical to establish students' understanding of the main concepts and be able to communicate them to others. This also has a huge impact on the academic achievement of students since. Students who have good scientific reasoning will also have good academic achievements, therefore, broader thinking and conceptualized analysis can be obtained to conduct easier understanding on the materials and concepts. Scientific reasoning can not only increase cognitive aspects but also improve the psychomotor abilities of students (Handayani, 2014).

Scientific reasoning plays a big role in the cognitive skills of students, however, research in terms of identifying scientific reasoning abilities, especially in biology learning, is still limited. Due to that reason, this underlies researchers to conduct more research on this specific matter, scientific reasoning. The purpose of this research was to identify students' scientific reasoning reasoning in order that it affects the development of scientific reasoning abilities as a 21st century learning paradigm in the learning process of biology. The final results of this study are expected to be the foundation for empowering students' scientific reasoning ability.

II. RESEARCH METHODS

This research is a descriptive study conducted by observing and analyzing the scientific reasoning abilities of research subjects without any treatment. The subjects of this study were students of class X MIPA 2 and X MIPA 3 at SMA Adabiah Padang in the academic year 2020/2021. The instrument used was a test of scientific reasoning ability on virus material. The test was essay questions with a total of 12 items consisting of 8 content questions and 4 reasoned questions. This instrument is based on Lawson's Classroom Test of Scientific Reasoning. Indicators of scientific reasoning ability used are guided by four of the five aspects of scientific reasoning according to (Daryanti, 2015), namely argumentation, knowledge, analysis, and conclusions. The four selected aspects are shown in 12 essay items which are presented in Table 1.

Tabel 1. Scientific Reasoning Aspects in Instrument

Aspects of Scientific Reasoning	Indicators	Numbers of question
Argument	Give the argument logically through a hypothesis	7,8,9,10
Knowledge	Provide basic information on knowledge that is relevant to literacy outcomes.	1,2,3
Analysis	Analyze by connecting the facts from the results of literacy and examining the results of the analysis with clear reasons based on the theory and results of literacy.	4,5,6
Conclusion	Draw conclusions based on goals and distinguish causal relationships from decisions taken.	11,12

Aspects of Scientific Reasoning	Indicators	Numbers of question

The data was collected from the scientific reasoning ability followed by analyzing the scientific reasoning ability on each indicator into categories. To show the category of scientific reasoning ability for each indicator, researchers made conclusions based on the scientific reasoning ability category scale according to Rhodes which is presented in Table 2.

Table 2. Criteria for Scientific Reasoning Ability for each Indicator

Criteria	Scor
Benchmark (Low)	1
Milestone (Medium)	2 and 3
Capstone (High)	4

(Rhodes, 2010)

After categorizing the scientific reasoning abilities on each indicator, the next step was to add up all the scores obtained on each indicator of each student. To show the category of students' scientific reasoning abilities, the researcher explained the conclusions as presented in Table 3.

Table 3. Criteria for Students' Scientific Reasoning Ability

Scor	Criteria
$12 \leq s \leq 24$	Low
$25 \leq s \leq 36$	Medium
$37 \leq s \leq 48$	High

s = total score

(Rhodes, 2010)

III. RESULTS AND DISCUSSION

The scientific reasoning ability test was carried out in November 2020 at SMA Adabiah Padang of the academic year 2020/2021 in class X MIPA biology discussing virus material. The results based on the objectives of this study concerned on reasoning abilities of students. This scientific reasoning ability test consisted of 12 essay questions, where score 1 was considered as low reasoning ability, score 2 or 3 was considered as medium, and score 4 was considered as high reasoning ability. The scores were added together, then grouped based on the criteria of scientific reasoning ability.

Table 4. Results of Classification of Scientific Reasoning Ability Based on Number of Students.

Class	Low	Medium	High
X MIPA 2	17	14	0
X MIPA 3	18	14	0
Total	35	28	0

This study was conducted in two classes of X MIPA, namely X MIPA 2 and X MIPA 3 with a total of 63 students at SMA Adabiah Padang academic year 2020/2021 who were biology material about viruses. The results showed that the classification of the scientific reasoning abilities of students was mostly in the low category with a total of 35 students. In the medium criteria, 28 students were identified. The results also presented that there are no students classified in the high reasoning ability. Based on the data, it can be concluded that the scientific reasoning abilities of the two classes are in the low and medium criteria, and none of the students from the two classes have the high category of scientific reasoning ability. The comparison of the percentage results of the classification of scientific reasoning abilities from these two classes can be seen in Figure 1.

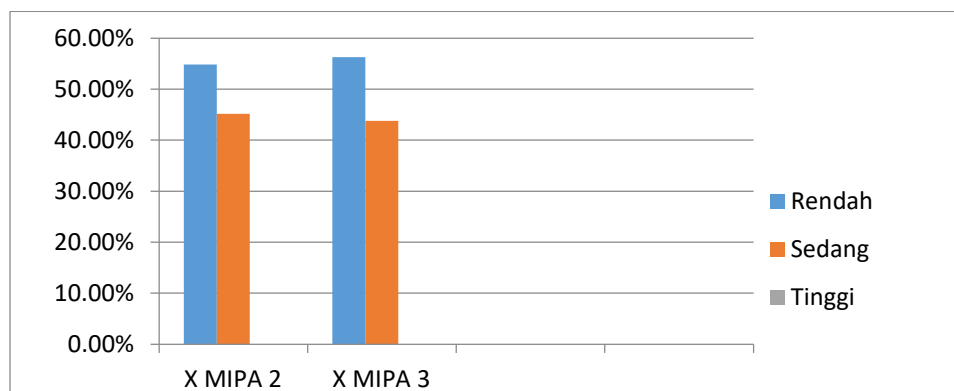


Figure 1. Comparison of the Percentage Results of Classification of Scientific Reasoning Ability of the Two Classes

After obtaining the data in table 4, then identify the scientific reasoning ability of each indicator. Based on the test results, the following results were obtained:

1. Scientific Reasoning Ability of Class X MIPA Students 2

Based on the results of research conducted in class X MIPA 2 SMA Adabiah Padang with 31 students, the results of scientific reasoning abilities can be observed in Figure 2.

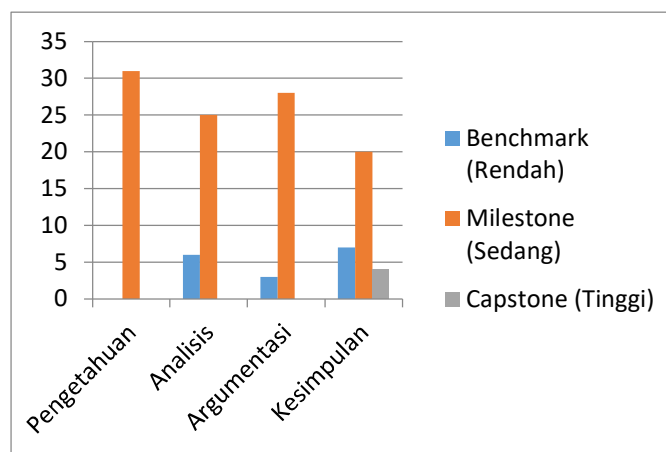


Figure 2. Achievements in the Scientific Reasoning Category Based on the Number of Students in Class X MIPA 2.

The scientific reasoning ability of students shows that the scientific reasoning aspects of knowledge were in the milestone criteria (medium) for all 31 students, so it can be concluded that there were 31 students who are able to explain basic information / knowledge concepts relevant to the problem clearly but not in detail as the explanation is based on existing theory.

In analysis criteria, there were 25 milestone type students (moderate) and 6 benchmark type students (low), so it could be concluded that these 25 students were able to analyze the data clearly by connecting the facts obtained from the results of literacy

and knowledge yet still lacking in detailed information. There were also 6 students who were only able to analyze the data without relating it to literacy and knowledge.

In the aspect of argumentation, there are 3 students with the benchmark type (low) and 28 categories of milestones (medium). It can be concluded that in this aspect of the analysis 3 students still provide logical arguments / reasons but are not based on the concept of knowledge and literacy results that are clear, logical and relevant to the results of the analysis and 28 other participants are able to provide logical arguments or reasons based on the concept of knowledge and literacy results that are clear and relevant to the results of the analysis but are still less detailed.

In the conclusion aspect, there were 7 students in the benchmark category (low), 20 with the milestone type (medium) and 4 with the capstone type (high). It can be concluded that in this aspect of the conclusion there were 7 students who still stated ambiguous, illogical and inconsistent conclusions with the theory and analysis results. Then, there were 20 students who have been able to state conclusions but only focus on existing theories without any reasons for the results. analysis and there are 4 students who have been able to state conclusions correctly and clearly and have been accompanied by reasons based on the theory and results of the analysis.

2. Scientific Reasoning Ability of Class X MIPA Students 3

Based on the results of research conducted in class X MIPA 3 SMA Adabiah Padang with 32 students, the results of scientific reasoning abilities are as shown in Figure 2.

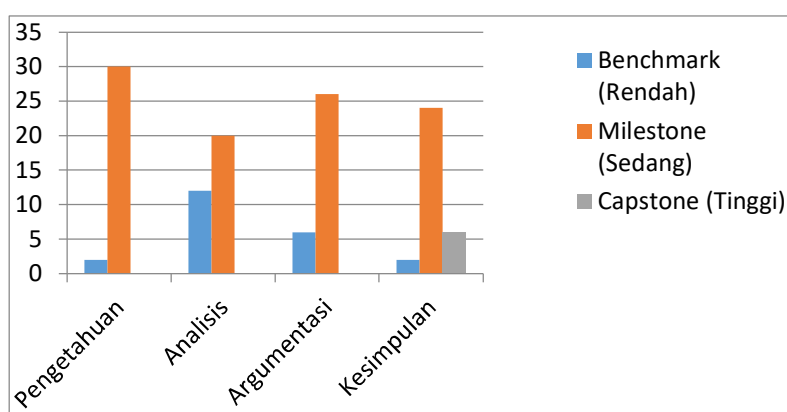


Figure 2. Achievements in the Scientific Reasoning Category Based on the Number of Students in Class X MIPA 3

The scientific reasoning ability of students shows that there were 30 students categorized as milestone (medium), and there were 2 students in the low category, so it can be concluded that 30 students are able to clearly explain basic information / knowledge concepts relevant to the problem but lack in giving detailed information based on existing theories. The other 2 students explained basic information / knowledge concepts that were relevant to the problem but not according to existing theories.

In analysis criteria, there were 20 students found in the milestone category and 6 benchmark categories, so it can be concluded that these 20 students were able to analyze the data clearly by connecting the facts obtained from the results of literacy and knowledge and there were 6 students who were only able to analyze data without relating it to facts obtained from their literacy and knowledge.

In the aspect of argumentation, there were 6 students in the benchmark category and 26 students in the milestone category. It can be concluded that in this aspect , 6 students still provide logical arguments / reasons, but those were not based on the concept of knowledge and literacy that are clear, logical and relevant to the results of the analysis. On the other hand, 26 other participants were able to provide logical arguments or reasons based on their knowledge and literacy that are clear and relevant to the results of the analysis, but the arguments were still less detailed.

In the conclusion aspect, there were 2 students in the benchmark category, 24 in the milestone category, and 6 people in the capstone category. It can be concluded that in this aspect of the conclusion, 2 students stated ambiguous, illogical and inconsistent conclusions with the theory and analysis results. There were 24 students who have been able to state conclusions but only focus on

existing theories without any reasons for the results analysis. Then, it is followed by 6 students who have been able to state conclusions correctly and clearly followed by reasons based on the theory and results of the analysis.

The results of this study indicate that the average scientific reasoning ability of class X students at SMA Adabiah Padang is low. The researcher inferred that this is due to the lack of motivation to learn. In addition, the biology teacher at SMA Adabiah Padang has never measured students' scientific reasoning abilities including the lack of variation in the learning provided by the teacher.

The factors that affect learning consist of internal (from oneself) and external (from outside) factors. Based on observations during the study, students experienced internal factors such as fatigue during learning, especially during afternoon lessons. The fatigue factor experienced by students is generally spiritual fatigue. Spiritual fatigue can be seen from the presence of lethargy and boredom during learning, so that interest and motivation to learn are reduced. Slameto (in Mulyani, 2013) states that spiritual tiredness can occur when constantly facing things that are always the same and constant without any variation. This also might occur when someone is forced to do things which are not in accordance with their talents, interests, and concerns.

External factors experienced by students are related to school factors. In its implementation, SMA Adabiah Padang was found to have issue with discipline, which affects the attitudes of students in learning causing students to be less responsible. Students who do not carry out their duties are not given strict sanctions. Therefore, discipline is a crucial matter in the learning process to develop strong learning motivation.

The teacher's role in giving examples and questions can also affect the scientific reasoning abilities of students. Teachers at SMA Adabiah Padang tended to give relatively easy questions, for example daily test questions whose answers can be copied from books or biological literacy. Teachers did not provide examples of scientific reasoning skills or higher order thinking problems to students. Teachers are advised to familiarize students by giving questions that spur higher-order thinking skills, especially their scientific reasoning abilities.

One of the reasons scientific reasoning needs to be established since an early age from students according to Lawson (2004) is to solve problems in learning as it is related to understanding the main concepts of science and in order to communicate them to others. Furthermore, Bao, et al. (2009) stated that high scientific reasoning ability allows students to solve problems in new situations, besides being able to design investigations to solve existing problems. Scientific reasoning can be improved by providing a learning model that triggers the higher order thinking skills of students.

IV. CONCLUSION

This study was conducted at SMA Adabiah Padang with a total of 63 students from two classes with details 31 students from X MIPA 2 and 32 students from X MIPA 3 of the academic year 2020/2021. The students involved were learning biology on the specific topic about viruses. The results showed that the percentage of the scientific reasoning abilities of the two classes was almost the same. Both classes as seen from the total results of students' scientific reasoning abilities were in low and moderate criteria.

The results show that many students have low scientific reasoning skills. In both classes, the lowest scientific reasoning ability was found in the indicators of analysis and argumentation. Meanwhile, the best reasoning skills were in the indicators of knowledge.

REFERENCE

- [1] Bao, L., Cai, T., Koenig, K., Fang, K., Han, J., Wang, J., et al. (2009). Learning and scientific reasoning. *Science*, 323(5914), 586-587.
- [2] Bao, L., Cai, T., Koenig, K., Fang, K., Han, J., Wang, J., et al. (2009). Learning and scientific reasoning. *Science*, 323(5914), 586-587.
- [3] Daryanti, E. P. (2015). Peningkatan Kemampuan Penalaran Ilmiah Melalui Model Pembelajaran Inkuiri Terbimbing pada Materi Sistem Pernapasan Manusia. *Jurnal Pendidikan Matematika dan Sains*, 3(2), 163-168.
- [4] Handayani, S. S. (2014). Pembelajaran Biologi Dengan Concept Attainment Model Menggunakan Teknik Vee Diagram dan Concept Map Ditinjau dari Kemampuan Berpikir Kritis dan Penalaran Ilmiah. *Jurnal Inkuiri*, Vol 3. No. II (16-27).
- [5] Koenig, K. S. (2012). Explicitly Targeting Pre-Service Teacher Scientific Reasoning Abilities and Understanding of Nature of Science through an Introductory Science Course. *Science Educator*, 21(2).

- [6] Lawson, A. E. (2004). The Nature and Development of Scientific Reasoning:. *International Journal of Science and Mathematics Education*, 2: 307–338.
- [7] Lee, C. Q. (2010). Facilitating students conceptual change and scientific reasoning involving the unit of combustion. *Research in Science Education*, 40(4),479-504.
- [8] Mulyani, D. (2013). Hubungan Kesiapan Belajar Siswa dengan Prestasi Belajar. *Jurnal Ilmiah Konseling*, Volume 2. No 1: 27-31.
- [9] Purwana. U, L. d. (2016). Profil Kompetensi Awal Penalaran Ilmiah (Scientific Reasoning) Mahasiswa pada Perkuliahan Fisika Sekolah. *Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains*, p.753-756.
- [10] Rhodes, T. (2010). *Assessing outcomes and improving achievement: Tips and tools for using rubrics* . Washington DC: Association of American Colleges & Universities.
- [11] Tapilouw, K. M. (2015). Pengaruh Model Inkuiri Ilmiah terhadap Peningkatan Keterampilan Proses Sains Siswa SMP pada Materi Kalor dalam kehidupan. *EDUSAINS*, VII (1): 88-96.
- [12] Wijaya, E. Y. (2016). Transformasi Pendidikan Abad 21 Sebagai Tuntutan Pengembangan Sumber Daya Manusia di Era Global. *In Prosiding Seminar Nasional Pendidikan Matematika*, (Vol. 1, No. 26, pp. 263-278).