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Assessment of biological literacy for high school students

Anggi Putri Suhadi*, Rizhal Hendi Ristanto, Diana Vivanti Sigit, Supriyatin

Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, Indonesia

*Corresponding author: suhadianggiputri@gmail.com

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ABSTRACT

Biological literacy is the individual's ability to determine the prior knowledge to understand the terms, concepts, procedural, benefits, and relationships of biological sciences in life. This study aims to measure students' biological literacy skills. This study approach was conducted descriptively, with grades, levels, and material indicators utilized to assess biological literacy skills. The population in this study was students from grade X Mathematics and Natural Sciences, Baitul Qurro Islamic Senior High School, with a sample size of 44 students drawn from the overall population. The instrument employed was a multiple-choice with up to 15 items about viruses related concepts. The data were analyzed descriptively. The results of this study revealed that 50% of students have low biology literacy skills. The highest percentage of students' biological literacy skills was found in indicator 4 (interpreting the role of viruses in life), 61%, while the lowest was in indicator 3 (analyzing virus replication), with 42%. The percentage of students' literacy skills in each level of biological literacy was highest at the structural level, with 58%, while the lowest was at the nominal level, with 44%. The low level of student biological literacy indicates that research is needed to find the right strategy to improve biological literacy skills in learning.

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INTRODUCTION

Literacy in reading and writing, mathematics, and science are the skills and talents that must be had in the twenty-first century (Pakpahan, 2017). Indonesia has regularly been one of the countries with the lowest PISA ranks for the last ten years. According to PISA statistics, the standard literacy level of Indonesian students is still at level 2, wherein data in 2018 showed that 70% of Indonesian students are below the minimal reading proficiency level, 71% in maths, and 60% in science (Fahlevi, 2021).

Scientific literacy skills play a role in supporting students in making decisions to solve problems (Fakhriyah et al., 2017). Furthermore, scientific literacy could be promoted by the skill of problem-solving in personal and social life (Lederman et al., 2013). Close scientific literacy skills related to the economic development of a country. People who are objective, process, and have qualified scientific skills will print reliable experts, scientists, engineers, and professors who can improve the country's economy (Windariani, 2017).

The goal of science education is the formation of scientific literacy (Birzina, 2016). The development of science process skills, especially biology learning in schools, needs to be implemented to achieve this goal (Sudarisman, 2011). The biology learning process consists of four components: scientific attitudes, scientific processes, scientific products, and the application of scientific methods (Susilowati in Agustiawan & Puspitasari, 2019).

Biological literacy receives less attention in the educational literature when compared to scientific literacy. According to the EBSCOhost database, during the 1954 – 2020 period, 11629 scientific literacy articles were found, but there were only 584 articles that used the term biological literacy (Semilarski & Laius, 2021). The difference is the ratio of 1: 19, where there is only one biological literacy article published compared to 19 scientific literacy articles. Several studies found that students' initial biological literacy skills on reproductive material were low, with an average score of 58.25 (Djamahar et al., 2021), and biological literacy students at four levels scored below 50% (Mahardika et al., 2016).

The RMS (Reading, Mapping, and Sharing) application, based on the bioreprodepedia website, successfully develops biological literacy (Djamahar et al., 2021). Biological literacy on any biological material, particularly virus material, is still difficult to obtain using the Publish or Perish 7 program and Google Scholar. The virus is one of the abstract materials, which may explain why pupils are uninterested in studying viruses (Darmawan & Nawawi, 2020). Therefore, it is necessary to do a lot of research on students' biological literacy skills as references to find the right strategy to improve students' biological literacy in learning.

Based on the problems above, the researchers conducted this study to measure the biological literacy skills of students on virus material as a preliminary study for further research on students' biological literacy skills.

METHODS

Research Design

This study is based on descriptive research, which seeks to understand existing events or occurrences (real issues) and then depicts them as they occur (Kurniadi, 2011). Descriptive research focuses on independent variables (one variable) and does not involve comparing or linking variables (Sugiyono, 2016).

Population and Samples

This study's population consisted of 44 students from grade X Mathematics and Natural Sciences, Baitul Qurro Islamic Senior High School, which included classes X Mathematics and Natural Sciences 1 and X Mathematics and Natural Sciences 2. Arikunto (2013) states that if there are less than 100 people, it is better to take all of them so that the research is a population study. However, if the number of subjects is large, it can be taken between 10-15% or 20-25%. Based on the above, the total sampling technique was used in sampling because the population was less than 100. So that the entire population of 44 students from grade X Mathematics and Natural Sciences, Baitul Qurro Islamic Senior High School, became the sample in this study.

Instrument

This study used a test instrument that includes a 15-question literacy-based multiple-choice test on virus content. The test set must be checked for practicality outside the sample, including validity testing using the biserial point correlation approach (Rahayu & Djazari, 2016) and the difficulty level of the questions using the difficulty level categorization (Sudjana, 2014). The instruments for biological literacy are listed in Table 1.

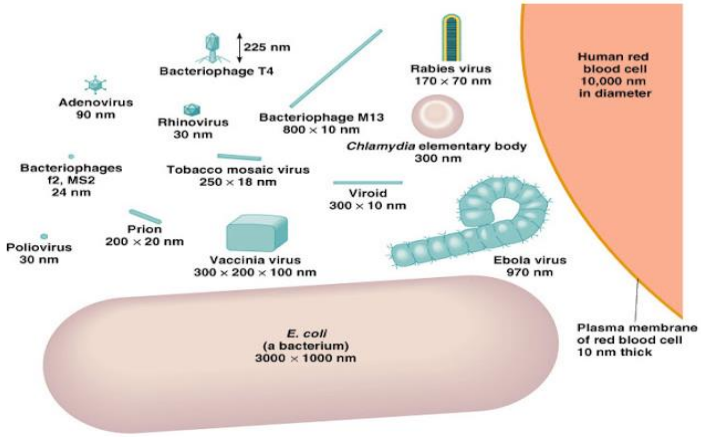
Table 1

Components of the viruses material biological literacy test instrument

Indicator	Level	Question number
Identify viruses characteristic	Nominal Functional	1, 2 3, 4
Explain viruses structure	Functional Nominal	5 6
Analyze viruses replication	Multidimensional Functional	7 8, 9
Explain and interpret viruses' roles in life	Structural Multidimensional	13, 14 10, 11, 12,15

Table 2

Examples of biological literacy questions at each level

Question number	Level	Question	Answer
1	Nominal	Take a look at the image below!  A comparison of the sizes of viruses, bacteria, and eukaryotic cells is shown in the image above. Which of the following statements about the properties of the viruses is right... A. Viruses are acellular, prokaryotic organisms that contain nucleic acids and may live freely in the air. B. Acellular, obligate parasitic viruses measuring 200-300 nm contain DNA/RNA. C. Viruses are small, cellular, eukaryotic organisms that live in plants and animals and have DNA. D. Viruses with a 10–100 nm diameter are obligate parasites and contain nucleic acids.	B
2	Nominal	The word "virus" originates from the Latin word "vires," which means "poison." In 1883, a German scientist called Adolf Mayer identified the virus while examining the origin of mosaic disease in tobacco plants. Adolf Mayer did a trial in which he took an extract from a diseased plant and sprayed it on healthy tobacco plants, which caused the healthy plants to become sick. He then checked	D

Question number	Level	Question	Answer
		under the microscope but was unable to locate it. Mayer believes some germs are smaller than normal and can't be seen with a microscope. Over the next few decades, scientists continued to study the "mosaic." Which scientist is the next to play a role, and which of the following results is the most suited... A. The sickness was discovered to be caused by a pathogen capable of replicating up to multiple times after transmission by A. Dmitri Ivanovsky (1892). B. The pathogens that produce mosaics, according to B. Wendel Stanley (1935), are filterable viruses. C. Mosaic illness is caused by very microscopic particles, according to C. Martinus Beijerinck (1897). D. The Tobacco mosaic virus was named after D. Wendell Stanley (1935), who discovered that the pathogenic particles of tobacco plants could be crystallized (TMV).	
4	Functional	Viruses, according to some scientists, are not living organisms. Some biologists, on the other hand, consider viruses to be living creatures. Which of the following reasons for the preceding statement is the most relevant... A. Inanimate things: viruses are not cells since they can crystallize. They can only exist in other living cells. Living things: because it can reproduce, its body consists of nucleic acids (DNA / RNA) B. Living things: viruses can reproduce because they have cytoplasm, cell organelles, membranes, and a nucleus. Inanimate things: because they have a capsid C. Inanimate things: since it is parasitic and may crystallize. Living things: because they can replicate and are multicellular D. Living things: the capsid is made up of proteins and nucleic acids. Inanimate things: because they can be filtered with filterable viruses	A
7	Multidimensional	Hepatitis is one of the world's most serious health problems. Hepatitis is a virus-caused illness of the liver and bile ducts that bodily fluids and patient-used eating and drinking utensils can spread. Hepatitis is divided into five types: A, B, C, D, and E. According to the Basic Health Research (Riskesdas) conducted by the Indonesian Ministry of Health in 2014, 10 out of 100 Indonesians are infected with hepatitis B or C. This indicates that 28 million Indonesians are hepatitis B and C afflicted. Fourteen million (14) of them have the potential to proceed to chronic hepatitis, and 14 million chronic hepatitis patients are at high risk of developing liver cancer. As a result, Indonesia is the ASEAN country with the second-highest number of Hepatitis B cases. Hepatitis may be treated in various methods, one of which is the use of protease inhibitor antiviral medicines, which stop the virus from reproducing and prevent it from spreading. These medications can be taken orally treatment. Viruses can multiply through lytic and lysogenic cycles, as depicted in the diagram below.	C

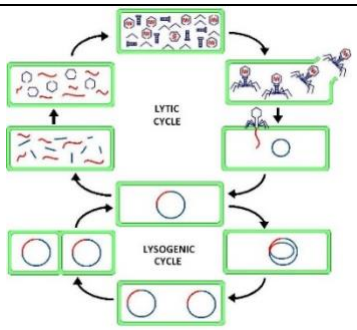
Question number	Level	Question	Answer
		 Protease antiviral medicines effectively slow the rate of virus reproduction; at which stage of reproduction? A. The lysogenic cycle includes injection and eclipse. B. The lysogenic cycle involves both synthesis and lysis. C. Synthesis and assembly in the lytic cycle D. Injection and maturation in the lytic cycle	
13	Structural	Take a look at the image below!  What conclusions can you draw from the look of the leaves on some of the plants mentioned above? A. Insects create leaf disease, which causes the leaves to curl and spread in the wind. B. Yellow patches develop on the leaves of plants infected with viral mosaics, which spread swiftly through insects. C. The sickness produced by the tungro virus affects the leaves, causing them to get damaged and shrink. D. Pests wreak havoc on the leaves, forcing them to wither and perish.	B

Table 3
Validation Test Results

No	rcount	rtable	Conclusion	No	rcount	rtable	Conclusion
S1	0,47	0,45	Valid	S11	0,74	0,45	valid
S2	0,65	0,45	Valid	S12	0,33	0,45	valid
S3	0,49	0,45	Valid	S13	0,64	0,45	valid
S4	0,53	0,45	Valid	S14	0,61	0,45	valid
S5	0,51	0,45	Valid	S15	0,60	0,45	Invalid
S6	0,53	0,45	Valid	S16	0,28	0,45	Invalid
S7	0,39	0,45	Invalid	S17	0,11	0,45	Invalid
S8	0,53	0,45	Valid	S18	0,64	0,45	valid
S9	0,48	0,45	Valid	S19	0,49	0,45	valid
S10	0,21	0,45	Invalid	S20	0,50	0,45	valid

The validity of the questions was tested on 20 items, with the findings revealing that 15 were valid and five were invalid. If the conditions are met, the question items are considered legitimate $r_{count} \geq r_{table}$. In the level of significance, $\alpha = 0,05$ obtained $r_{tabel} = 0,45$ so that 15 valid items were used as test instruments.

Table 4
The difficulty level

No	Difficulty level		No	Difficulty level	
	Score	Criteria		Score	Criteria
S1	0,78	Easy	S9	0,26	Difficult
S2	0,42	Medium	S10	0,36	Medium
S3	0,57	Medium	S11	0,21	Difficult
S4	0,63	Medium	S12	0,15	Difficult
S5	0,36	Medium	S13	0,21	Difficult
S6	0,78	Easy	S14	0,21	Difficult
S7	0,63	Medium	S15	0,78	Medium
S8	0,52	Medium			

The difficulty level of the questions was tested on 15 items, with the findings revealing that two items (13%) were easy questions, eight items (53%) were medium, and five items (34%) difficult questions—the difficulty level of the questions using the difficulty level categorization (Sudjana, 2014).

Procedure

The implementation step is conducting research with 44 students in grade X Mathematics and Natural Sciences, Baitul Qurro Islamic Senior High School, giving an offline multiple-choice exam (PG) with up to 15 questions over 45 minutes, and regulating the status of the class so that no students see each other's responses. Multiple-choice tests cover a large range of subjects, are simple to grade, and offer a high degree of impartiality (Hanifah, 2014). The instruments are initially tested on students, followed by a preparatory exam that includes the validity test and difficulty level on biological literacy questions (Yusup, 2018). The data processing step analyzes the student's biological literacy test data.

Data Analysis Techniques

Data analysis in this study used a quantitative descriptive technique. The data to be analyzed is the value of students' biological literacy abilities, biological literacy in each indicator, and biological literacy in each level of biological literacy. There are 15 biological literacy questions with an objective test, notably the multiple-choice model, with a score based on score of 1 for correct answers and 0 for incorrect ones (Khaerudin, 2016). It will be interpreted into percentages and grouped into high, satisfactory, less than satisfactory, and low categories (Arikunto, 2013).

RESULTS AND DISCUSSION

This study's findings include an interpretation of the value of students' biological literacy skills, biological literacy in each indicator, and biological literacy in each level of biological literacy.

Biological Literacy Skills of Students on Virus Material

Based on data analysis from student literacy exams on virus material with 44 students, the best score is 100, the lowest score is 33.33, the average ideal score (Xi) is 66.67, and the ideal standard deviation (SDi) = 11.11. The results of the biological literacy skills of grade X Mathematics and Natural Sciences students at Baitul Qurro Islamic Senior High School are listed in Table 5.

Table 5
Biological Literacy Skills of Students on Virus Material

Range of value	F. Absolute	F. Relative	Category
83.33- 100	2	5%	High
66.67- 83.33	7	16%	Satisfactory
50 - 66.67	13	30%	Less than satisfactory
50- 0	22	50%	Low

Based on Table 5, Biological Literacy Skills of Students on Virus Material, a comparison chart of the levels of Biological Literacy Skills of Students on Virus Material can be shown in Figure 1.

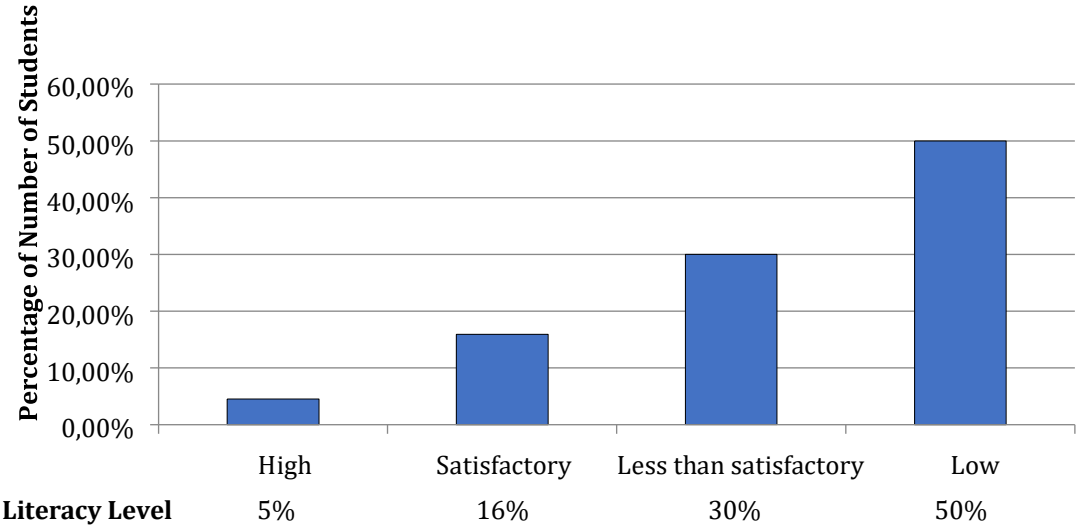


Figure 1. Graph of Comparison of Students' Biological Literacy Levels on Virus Material

According to Figure 1, as many as 5% of students have a high reading level on virus material, 15.90% have a satisfactory literacy level, 30% have a less than satisfactory literacy level, and 50% of students have a low literacy level.

Students' Literacy Level in Each Question Instrument Indicator

The proportion of students' literacy levels in each instrument indication on the virus material may be studied based on the scores obtained in each item of questions answered by students, as indicated in Table 6.

Table 6
The literacy levels of students for each question indicator.

No	Indicator	Indicator percentage	Category
1.	Identify viruses characteristic	47%	Middle
2.	Explain viruses structure	51%	Middle
3.	Analyze viruses replication	42%	Middle
4.	Explain and interpret viruses' roles in life	61%	High

According to Table 6, the percentage of students who can explain and interpret the role of viruses in life (Indicator 4) is 61%; explaining and interpreting the structure of the viruses (Indicator 2) is 51%; identifying viruses traits (Indicator 1) is 47%, and analyzing viruses replication (Indicator 3) is 42%.

Biological Literacy of Students in Each Level

The proportion of students' literacy levels in each level of biological literacy on virus material may be studied based on the scores obtained in each level of questions answered by students, as indicated in Table 7.

Table 7
The biological literacy of students results at each level

No	Level	Question Points	Percentage (%)	Category
1.	Nominal	1,2,6	44	Low
2.	Functional	3,4,5,8,9	51	Middle
3.	Structural	13,14	58	Middle
4.	Multidimensional	7,10,11,12,15	55	Middle

Based on Table 7 Biological literacy of students results at each level comparison chart can be shown in Figure 2.

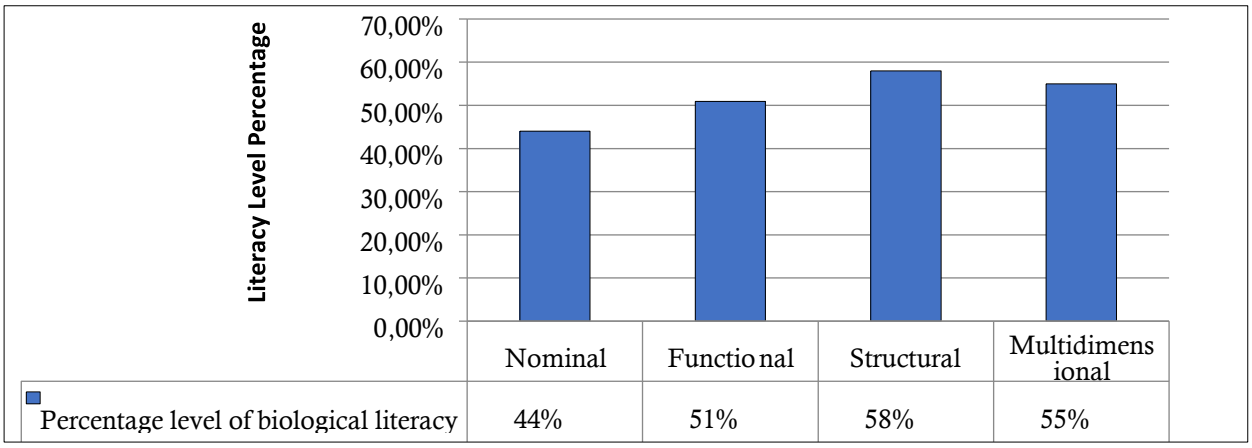


Figure 2. Student Biological Literacy Results at Each Level

According to Figure 3, the percentage of students' literacy levels on virus material is increasing from highest to lowest, with a structural level of 58%, a multidimensional level of 55%, a functional level of 51%, and the nominal level of 44%.

The data analysis results show that students' biological literacy skills on virus material are mostly at a low level; namely as much as 50% or half of the total students still have low biological literacy skills. Meanwhile, students with high biological literacy skills were found to be at least 5%. This is consistent with the findings of (Fadilah et al., 2020) research, which revealed that students' biological literacy abilities were categorized with an average accomplishment of 40.5 percent. She went on to say that the findings were in line with the pupils' capacity to evaluate, create concepts, and solve issues included in the questions. Given that today is the age of biology, one of the challenges that must be addressed as soon as possible is the poor value of students' biological literacy (Sudjana, 2014).

The substance employed in this investigation is a virus. Viruses are a complex and abstract subject; in practice, they necessitate specialized equipment and are hampered by the dangers they represent (Darmawan & Nawawi, 2020). Students will be familiar with reading tasks, problem-solving, finding answers, and making judgments based on the information offered in the questions after working on literacy-based questions on virus material. When the indicator on the virus material is seen, the highest value on the indicator interprets the virus's part in life with a percentage of 61% (Table 6). Students find it easier to answer issues that arise in their daily lives, such as how students choose vaccines, follow health protocols, and propose solutions to virus-related problems; however, the lowest indication is about assessing viral replication. The virus goes through stages of viral reproduction to develop and reproduce itself. Students struggle to analyze and answer problems. Students are still unable to incorporate concepts and terminology into their execution. Students were given readings and

then asked how the mechanism of antiviral medications works in limiting the rate of virus reproduction, same as they did with hepatitis questions. This is consistent with the findings of a study done by Post et al. (2017), which found that students had poor decision-making and creative fluency regarding biological literacy.

When students' biological literacy level is examined from each dimension, the structural dimension has the greatest rate of 58% (Table 7). This demonstrates that class X SMA IT Baitul Qurro can assess a biological concept's scheme, chart, and procedure. The capacity to understand data, pictures and schematics is a talent and aptitude that students must have in this revolutionary period. The growth and state of the covid-19 epidemic are displayed on social media, the internet, and numerous mass channels, allowing students to address problems at a structural level. It also demonstrates that learners' capacity to use it in comprehending biological phenomena and concerns is required (Zaki, 2012). The nominal dimension achieves the lowest level with a percentage of 44%. This demonstrates that students have trouble remembering biological terms. Students can recognize biological terminology and concepts since the qualities are at the nominal level. Many elements separate and determine a student's biological literacy skills. According to Huryah et al. (2017), the following elements impact students' biological literacy achievement: interest, learning intensity, learning techniques, reading interest, students' attitudes toward science, study habits, and learning methodologies. Instructors educate students.

Researchers conducted interviews with teachers who teach biology lessons in grade X Mathematics and Natural Sciences Baitul Qurro Islamic Senior High School to find out the reasons for students' low biological literacy skills. The teacher stated that the pandemic condition affected the teaching and learning process, especially the quality of learning; the quantity of learning was reduced, and the learning model used was limited because learning was done online. This is in line with research (Ankara, 2021) which states that the low multidimensional biological literacy among students can be explained by the lack of adequate opportunities and assignments that require students to use their previous knowledge and connect their biological knowledge with social life, technology, and science. This demonstrates that a lack of basic understanding can produce a poor level of biological literacy in students. This task requires students to apply prior information and integrate their biological knowledge with social life, technology, and other disciplines. Furthermore, a lack of comprehension of scientific concepts is frequently linked to learning activities that are still geared toward memorizing (retention), conventional learning techniques, and the content's difficulty level (Ariana et al., 2020).

Mukti, et al. (2019) suggested that innovative learning to empower students' scientific literacy skills needs to be introduced to biology learning. This is in line with Rahayu's (2017) suggestion that the teachers could enhance the scientific literacy of students by facilitating the students to have appropriate experience in science activities, investigation, and experimentation. Everything can be enhanced through an innovative learning strategy or model that is built by incorporating the elements needed for scientific literacy skills. Then, it will develop collaboration & communication skills, and the curiosity of students.

The Project-Based Learning (PjBL) learning model should be used to improve biological literacy since it allows students to apply their knowledge, practice problem-solving, and raise learning motivation (Rizkamariana et al., 2010). Students must be able to comprehend ideas such as biology, problem-solving, roles and responsibilities, and their link to society (social-biology). Qualified human resources must match technological and informatics advancements. Personal variables (self-confidence, metacognition, motivation, and so on) can contribute to low literacy in students, as can instructional elements (teacher quality and learning quality, such as techniques, tactics, models, and assessments), and environmental factors (culture, school climate, facilities and infrastructure, and family) (Mahdiansyah & Rahmawati, 2014). Based on research conducted by Hafitriani Rahayu et al. (2017), The PjBL learning model positively influences students' higher-order thinking.

Moreover, the integration of the PjBL Model with STEM (Science, Technology, Engineering, and Mathematics) or PjBL-STEM, is expected to provide opportunities for students to explore ideas, develop products, and improve design skills, so students will optimize in improving thinking skills high level (Windasari et al. 2020). STEM-PjBL is learning project-based by connecting science, technology, engineering, and mathematics. Based on research conducted by Jauhariyah et al. (2017), The PjBL-STEM model can provide students with experiences to learn context through complex activities such as exploring planning learning activities, carrying out projects with work the same, and produce a product.

According to Capraro et al. (2015) "The PjBL-STEM model will grow students to think analytically, creatively, critically, and improve thinking skills high level. Model PjBL-STEM feels right if it is implemented in learning to improve students' biological literacy skills.

CONCLUSION

Based on the study's findings, it can be stated that the biological literacy level of students in grade X Mathematics and Natural Sciences, Baitul Qurro Islamic Senior High School on viruses subject is in a low category, at 50%. Indicator 4: describing and understanding the function of viruses in life, had the largest proportion of students' biological literacy, at 61%, while indication 3: assessing viruses replication had the lowest, at 42%. The structural level had the largest percentage of students with biological literacy, at 58%, while the nominal level had the lowest number, at 44%.

This research is limited to measuring the biological literacy skills of students on virus material as a preliminary study. In the future, researchers will conduct research related to the STEM-PjBL (Science, Technology, Engineering, and Mathematics – Project-Based Learning) learning model to improve students' biological literacy skills.

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