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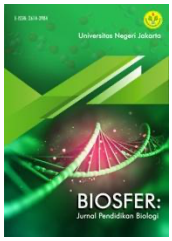

Improving student's biological literacy skills using ARVi learning media

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ABSTRACT

Biological literacy is crucial for students to consider solutions to problems after analyzing them from various perspectives. The purpose of this research is to enhance biological literacy by using ARVi (Augmented Reality Virus) learning media. The research type is a quasi-experiment using a control group pretest-posttest design. The research instrument is a multiple-choice test validated by experts and empirical validation. The expert validation result shows an average score of 3.8, which can be interpreted as the test instrument being valid and suitable for use as a biological literacy measurement tool. The empirical validation result indicates that 3 questions are invalid, while 17 questions are valid as a biological literacy measurement tool. The reliability test result shows that the biological literacy test instrument has a reliability coefficient of 0.835, which can be interpreted as 70% confidence that the instrument can be trusted. The data analysis result shows that the data is normally distributed and not homogeneous. The independent t-test result is a t-statistic of 3.16 with a t-table of 1.98 at an α=0.05. This indicates that there is an increase in results between the control group to experimental group. The paired t-test result is a t-statistic of 15.7 with a t-table of 0.68 at an α=0.05. This indicates that there is an increase in posttest results compared to pretest results. This indicates that the ARVi media can enhance all aspects of biological literacy. The highest increase in biological literacy occurs in the nominal (82%), multidimensional (64%), structural (52%), and functional (32%).

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INTRODUCTION

Biology literacy is an important part of science education that focuses on understanding biological concepts and processes. Biology literacy is part of science literacy, which is one of the goals of education (Elhai, 2023; Semilarski & Lalus, 2021). Biology literacy becomes a way to help learners understand nature (Adnan et al., 2021; Anakara, 2021). Biology literacy can be used to make informed decisions in solving problems, such as ecosystem restoration, human health, and renewable energy (Bennett, 2010; Giordano et al., 2023). As a natural science, biology contributes to supporting literacy to a higher degree than other sciences (Anakara, 2021; Nizomova, 2023).

Biological literacy refers to the ability to understand biological issues in society and integrate ideas when making decisions while also being able to communicate with others about these topics (Cartwright et al., 2020; McBride et al., 2013). Students who are literate in biology will view problems from various perspectives and make accurate decisions after considering different factors. An individual with biological literacy requires knowledge of biological concepts, historical developments, principles, environmental impacts, biotechnology, and its applications in social life (Kreher et al., 2021; Onel & Durdukoca, 2019).

Biological literacy can be divided into four levels: nominal, functional, structural, and multi-dimensional. Nominal literacy refers to students being able to identify terms or concepts that are part of the biological field (Ristanto et al., 2023; Uno & Bybee, 1994). Functional literacy occurs when students can define words from various perspectives (Kožuh & Čakš, 2023; Mahardika et al., 2016). Structural literacy happens when students understand how biological facts work, explain, and apply information in new situations while valuing the importance of biological information for themselves. The domain of multi-dimensional literacy means that students have a broad understanding of biology with details and interconnectedness with other fields (Anakara, 2021; Miller et al., 2022).

This research is based on an interview conducted by a biology teacher in March 2023. The interview was done to identify the challenges faced during biology learning and school facilities to support the use of learning technology. The interview results show that one of the 21st-century skills that students need to improve is literacy, specifically biological literacy. Several studies have shown that students have low levels of literacy (Adnan et al., 2021; Huryah et al., 2017; Mahardika et al., 2016). This indicates the need for efforts to improve biological literacy. Literate students can consider the benefits and risks faced by themselves and society from a biological perspective (Patenaude & Bloomfield, 2022; Yussof et al., 2012). If reading literature becomes a habit, it will increase cognitive abilities while also protecting against memory decline (Chang et al., 2021; Eekhof et al., 2022).

The topic of viruses is particularly challenging to learn due to its complexity. The virus material in the curriculum covers general characteristics, classification, replication stages, diseases, and benefits of viruses, including COVID-19. This complexity can be simplified by using educational media, such as augmented reality (AR). AR technology is a visual medium that plays a significant role in forming someone's memory. The use of AR allows students to observe viruses in 3D form, enabling them to view objects from all angles, zoom in and out, and explore the object. This is done to enable students to explore the virus object, which can then be stored in their memory, and their understanding increases. Three-dimensional images can enhance content value and the combination of text provides learner satisfaction (Tavanti & Lind, 2001).

ARVi (augmented reality virus) is an application designed to enhance the literacy of students. ARVi has several contents. The first content is about the concept of viruses, including their history and roles. The second content consists of various types of viruses presented in AR format. The third content includes 18 scientific articles aimed at enriching students' literacy. The fourth content is a quiz for practice after studying viruses. The AR-equipped ARVi technology can assist students in providing a visual representation of virus structure, thus enhancing the visualization of virus structure in greater detail, which helps students understand complex details better (Puspitasari et al., 2020). AR is also capable of helping students develop skills in interpreting and analyzing visual data (Arslantas & Gul, 2022; Avgerinou, 2009). This can involve identifying key features such as capsid, envelope, nucleic acid, and their interactions to form a virus. Additionally, the use of ARVi can make learning more enjoyable and interactive, thereby increasing student motivation and participation (Khade & Khade, 2016; Puspitasari et al., 2020).

One of the contents of ARVi is a scientific article aimed at enriching the literacy of students. Scientific articles can enhance students' understanding and connect them to real-world applications

(Gómez & Vázquez, 2022; Winslow, 2010). There are several themes in the articles, including diseases caused by viruses, the beneficial roles of viruses, and the impact of COVID-19 along with its solutions. Literacy evaluation can be conducted using multiple-choice instruments (Jufri et al., 2019; Vitasari & Supahar, 2018; Vonny et al., 2021). Multiple-choice tests are chosen because they can measure knowledge, be administered to students, and facilitate feedback after learning (Covacevich Catalina, 2014; Montes-Iturrizaga et al., 2023). Based on this explanation, research on the influence of biology literacy is conducted using the ARVi media.

METHODS

Research Design

The type of research is a quasi-experiment using a control group pretest-posttest design. The research was conducted at one of the schools in Bogor City, Indonesia. The research population consists of all students in class 10 and sample selection used simple random sampling. The sample consisted of 60 experimental group participants who used ARVi media, as well as 60 control group participants who used conventional media such as books and PowerPoint presentations.

Table 1.
Control group pretest-postest design

Pretest	Treatment	Postest
O_1	X_1	O_2
O_1	C	O_2

Note: O_1 = Pre-test; X= Treatment of experimental class with ARVI learning media; C = Control Class; O_2 = Post-test.

The research design uses two groups, a control group and an experimental group, which can be seen in Table 1. Each group is given a pretest before learning and a posttest after learning. The experimental class uses ARVi learning media, while the control class uses visual learning media.

Data Analysis Techniques

Validated instruments for assessing biological literacy will be administered to students through pretests and posttests. Then, the analysis is performed using dependent and independent tests. The dependent test uses normality and homogeneity tests. Normality is tested with the Kolmogorov-Smirnov (KS) test at an alpha level of 0.05. If the data shows a higher value than the alpha level, it is considered normally distributed. Homogeneity is tested with the F test at an alpha level of 0.05. If the data is both normal and homogeneous, hypothesis testing is done using two types of independent t-tests at an alpha level of 0.05. Independent t-tests are used to determine the effect of media ARVi on biological literacy between control groups and experimental groups. A paired t-test is used to find differences in pretest and post-test results. The percentage increase is calculated using Putrawan (2019), which is done by calculating the difference between the pretest and posttest results.

Instrument

The test instrument is organized based on the biological literacy by Uno & Bybee (1994) which consists of nominal, functional, structural, and multidimensional biological literacy as seen in Table 3.

Table 2.
Grid of Biological Literacy

Biological literacy	Characteristics	Item Number
Nominal literacy	1. Identifying terms and questions in biology 2. Explaining the concept of biology in general	1, 7, 11, 16, 19
Functional literacy	1. Defining terms accurately 2. Responding to problems faced	2, 5, 9, 15, 17
Structural literacy	1. Having procedural skills 2. Explaining biology concepts in one's own words	4, 6, 12, 13, 14
Mulitidimentional literacy	1. Understanding the interaction biology with other sciences 2. Connectiong between biology and society	3, 8, 10, 18, 20

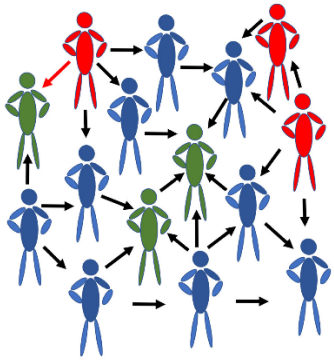
The instruments are made according to the characteristics of biological literacy and subconcepts

in the virus material. One example of a biological literacy question can be seen in Table 3.

Tabel 3.
Instrument and Biological literacy indicators

Sub-concept : COVID-19, impact and solution	**Biological Literacy :** Nominal Domain	**Answer: C**

The question :



19. Herd immunity, or group immunity, is indirect protection from infectious diseases when a population is immune through vaccination. For herd immunity to occur, it can be achieved by...
a. Green people getting vaccinated
b. Green people should be isolated
c. Blue people getting vaccinated
d. Blue people should be isolated
e. Red people should be isolated

Discussion :
Herd immunity is indirect protection from infectious diseases when a population is immune through vaccination. If blue individuals get vaccinated, they will protect green individuals who cannot be vaccinated from infected red individuals.

Source :
Gerstman, B. (2023). *Epidemiology kept simple : An introduction to traditional and modern epidemiology.* New Jersey: Wiley-Liss Inc. 72-73.

Before being given to students, the biology literacy test instrument undergoes validation and reliability testing. Validation is conducted by expert validators and empirical validation. Expert validation is conducted by biology professors and biology teachers. Expert validation uses a 1-4 scale questionnaire sheet.

Table 4.
Result of expert validation biology literacy instrument

No.	**Assessment Component**	**Score**	
		Validator 1	**Validator 2**
1	Topic on ARVi is in line with learning achievements	4.00	4.00
2	Topic on ARVi is in line with learning objectives	4.00	4.00
3	Comprehensive and systematic presentation	4.00	4.00
4	Accurate and up-to-date materials	3.00	4.00
5	Materials presented with suitable props	4.00	4.00
6	Language sustability with the level of thinking of students	4.00	3.00
7	Clear instructions for use	3.00	4.00
8	Language suitability with the level of thinking of students	4.00	4.00
9	Polite language usage	4.00	3.00
10	Text accuracy with materials	4.00	4.00
	Mean	**3.80**	**3.80**

The validation results for the biology literacy instrument in Table 4 show that the test instrument is valid, making it suitable for use as a measuring tool for biology literacy. Some suggestions for improvement include re-examining answer choices, explaining abbreviations, and ensuring high-quality images are included. These suggestions serve as a guide for revising the test instrument before conducting empirical validation tests.

Table 5.
Empiric validation results

Criteria	Literacy Domains	Number Item	Total
Valid	Nominal	1, 7, 11, 16, 19	5
	Functional	2, 5, 9, 15	4
	Structural	6, 12, 13, 14	4
	Multidimentional	3, 8, 10, 18	4
Invalid	Functional	17	1
	Structural	4	1
	Multidimentional	20	1

The empirical validation is calculated using the biserial point and can be seen in Table 5. The empirical validation results show that there are 17 valid questions and 3 invalid questions. This indicates that 17 questions are suitable for measuring biological literacy. The reliability test was conducted using the KR-20 formula. The results show a reliability coefficient of 0.835, which can be interpreted to mean that 70% of respondents are confident that the biological literacy test instrument can be trusted. This indicates that the biological literacy test instrument is ready to be used to measure biological literacy.

RESULTS AND DISCUSSION

The implementation of ARVi media was carried out for the experimental groups X-8 and X-9. Conventional visual learning media such as PowerPoint were used for the control groups X-5 and X-10. The difference in learning outcomes between the two groups can be seen through the results of the pretest and posttest.

Table 6.
Results of implementation of ARVi media towards biological literacy

No.	Data	Control Group		Experiment group	
		Pretest	Posttest	Pretest	Posttest
1.	Mean	49.11	63.78	53.22	81.67
2.	Minimum	18.33	28.33	18.33	65.00
3.	Maximum	76.67	88.33	78.33	95.00
4.	Standar deviation	20.57	19.59	21.62	10.16
5.	Students	60.00	60.00	60.00	60.00

Table 6 shows the results of using ARVi media in the experimental group and the control group. Based on the data, it can be observed that both groups have a higher average post-test value compared to the pre-test. The data underwent normality and homogeneity testing.

Table 7.
Results of normality testing

	α	Sig.	Category
Control group	0.05	0.20	Normal data
Expriment group	0.05	0.20	Normal data

Table 7 shows the results of the normality test using SPSS Statistics 23. Based on these results, it is known that the significance value is greater than the value of α. This means that the data is normally distributed.

Table 8.
Results of homogeneity testing

Data	F-value	F-table	Category
Pretest	0.91	3.15	Data homogen
Posttest	3.72	3.15	Data tidak homogen

Table 8 shows the results of a test for homogeneity using an F-test. The results indicate that the pretest

data is homogeneous while the posttest data is not homogeneous.

Table 9.
Independent t-test

	t-value	df	t-table	α	Interpretation
Equal variances not assumed	3.16	118	1.98	0.05	There are differences in posttest results between the control and experimental classes

Table 9 shows the results of an independent test. The result indicates that the calculated t-value (3.16) is higher than the t-table value (1.98), which means there is a difference in post-test scores between the control class and experimental group. This implies that the use of ARVi media affects biological literature performance.

The results were influenced by the use of Augmented Reality Virtual Interface (ARVI) during the experiment class. The augmented reality menu plays an important role to help students focus their attention on information presented through images, memories, and cognition. Simple information such as a 3D image and brief description of types of viruses is stored in short-term memory which can be recalled later for useful long-term memory (Jin, 2015). Iconic storage (visual effect) saves visual information using imagery coding similar to photo archives (Solso & Short, 1979).

Information stored in short-term memory needs to be effortfully transferred to long-term memory storage. Combining various pieces of information leads to the formation of more complex ideas, aiding in long-term memory retention. Learners using ARVi media can access information through literacy menus. Engaging with literacy menus prompts learners to explore diseases caused by viruses, enabling them to learn how to treat these illnesses as part of the benefits of virus use. This process makes information more meaningful, and relevant, and provides a strong rationale for learners to retain such memories (Ebbinghaus, 1885). This information is then stored in long-term memory, which proves useful in solving everyday problems (Hasanuddin, 2017; Musi, 2021). Establishing a habit of reading literature enhances cognitive abilities and safeguards against memory decline (Chang et al., 2021; Yussof et al., 2012).

Table 10
Result of Paired t-test

	Mean	t-value	t-table	df	α	Interpretation
Pretest Posttest	63.78 81.67	15.7	0.68	59.00	0.05	There is a difference between pretest and posttest

Based on Table 10, it is known that the value of t exceeds the table value, indicating an increase in biological literacy post-test compared to the pre-test. This is because the ARVi medium contains articles with various research topics such as the beneficial and detrimental roles of viruses, as well as articles about COVID-19 from its impact and solutions. The themes of these articles were chosen according to the free curriculum and suitability of the material to real-world contexts.

Every student meeting analyzes one article from one of the themes. Students can read comprehensively from the background of the issue, research methods used, research results, and discussion to conclusions. They can then summarize the essence of the presented article. Students only analyze one research article to facilitate the acceptance of new information and reduce cognitive load. Students can focus on the information presented and integrate it with existing knowledge. For example, students analyze an article on the effectiveness of hepatitis vaccination. Before reading the article, the brain will actively recall information about hepatitis, and then integrate it with new knowledge about hepatitis vaccines. If there is new information, it will be combined into one piece of information to reduce the amount of interacting information in working memory (Sweller, 1994).

Students who have analyzed an article and then present it to their classmates. This is a process of repetition and maintenance of information. The presentation activity prompts students to access their memory again and explain it in their own words. Subsequently, they will receive questions from their classmates, allowing them to explore their knowledge and potentially uncover different information beyond what was presented in the article. Literate students can construct their meaning about a subject based on available sources (Semilarski & Lalus, 2021).

After communicating with classmates, the learners also received new information from analyzing articles in different groups. This activity aims to provide learners with new information and perspectives, thereby strengthening their understanding of a topic. Knowledge from various literacies contributes to a more comprehensive understanding stored in long-term memory (Hutchison, 2018).

Table 11.
Results of Biological Literacy Analysis Experiment Group

No.	Data	Mean		% Improvement
		Pretest	Postest	
1.	Nominal	44.00	80.00	82%
2.	Functional	69.00	91.00	32%
3.	Structural	58.00	88.00	52%
4.	Multidimentional	47.00	77.00	64%

Table 11 shows the learning outcomes of a class that used augmented reality (AR) in their experiments. According to this table, each aspect of biological literacy had an average increase in value represented by a percentage growth rate. The nominal aspect had the highest percentage growth rate while the functional aspect had the lowest percentage growth rate.

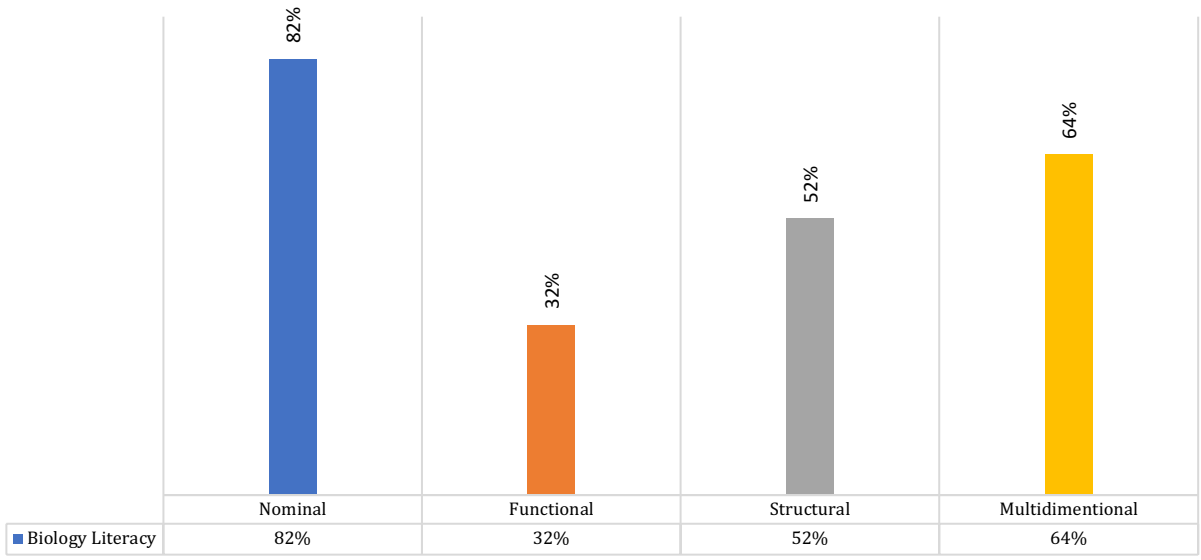


Figure 1. Percentage growth rate of biology literacy

Based on the posttest results of the experimental class, there was a significant improvement in all aspects of biology literacy (Figure 1). Augmented reality technology helps students observe the form of viruses and explore additional information provided in the ARVi media. Viruses in AR form contain structures, parts of the virus, and brief descriptions. Integrating knowledge of virus structure with biological literacy that includes life concepts contributes to a more comprehensive understanding stored in long-term memory (Hutchison, 2018).

The domain of nominal literacy shows the highest increase, which refers to the ability to identify words related to biology (Uno & Bybee, 1994). This is possible because augmented reality (AR) provides explanations for biological terms, allowing students to learn foreign vocabulary. Additionally, AR can help remember words associated with viruses such as capsid shape, DNA or RNA, capsomers, etc., making abstract concepts concrete and objects easier to remember (Omurtak & Zeybek, 2022). Previous research has shown that the use of AR can depict objects that are difficult to present in reality and transform them into three dimensions, thereby allowing abstract concepts to be substituted with tangible ones (Ahied et al., 2020; Wahyu et al., 2020).

The second highest increase occurred in multidimensional literacy, indicating that students can effectively find answers to problems from various readings (Juniarso, 2019). This is because ARVi discusses several benefits of viruses used as treatment methods, such as

vaccination, gene therapy, oncolytic therapy, and convalescent plasma therapy. This reading material becomes one of the alternative choices for understanding viruses as the cause of diseases. This aligns with previous research, which has shown that the use of scientific articles provides students with the opportunity to understand information from various articles, identify balance and bias, and provide comments on the scientific research itself (Elliot, 2014; Sundermann, 2019).

The highest increase occurs in structural literacy when students understand the concept of biology with the concept of life (Onel & Durdukoca, 2019), as shown in an article discussing the effectiveness of masks in spreading microorganisms (Asyari & Fadhilah, 2021).This article can serve as a strong inspiration for students to use masks when sick or to protect themselves from pollution. It provides valuable learning that can be applied in daily life (Noviana *et.al*., 2014). Based on previous research, AR is used to create an interactive experience that can visualize natural objects, allowing students to explore and interact with virtual models (Cahyana et al., 2023; Sulisetijono et al., 2023).

Functional literacy is the lowest improvement compared to other biology literacies. Students with functional literacy can define terms from various perspectives (Mahardika et al., 2016). This is caused by ARVi media not exploring the differences in terminology introduced by experts. By exploring various opinions, students can gain deeper insights, identify biases, and enhance creativity (Ghufron & Hardiyanto, 2017).Therefore, the use of ARVi should be balanced with a learning model that includes data collection stages like discovery learning. The data collection stage provides students with the opportunity to gather information from various sources. This stage involves activities such as reading literature, observing objects, and interviewing sources (Hanafi, 2016). Based on previous research, there is no specific information linking the use of augmented reality to functional literacy. However, there are studies on the implementation of multimedia use in functional literacy (Arpaci & Holland, 2023; Surwanti & Anatul Hikmah, 2019). Efforts to improve functional literacy can be made by using multimedia such as mobile apps, tablets, and computers combined with continuous practice with simple instructions that involve reading comprehension skills (Surwanti & Anatul Hikmah, 2019).

The overall use of ARVi media can influence the enhancement of biology literacy. ARVi media has an augmented reality menu that helps students visualize virus objects in 3D. This allows them to explore the virus shape from various angles and learn every detail they see. The use of scientific articles containing more specific information makes virus learning comprehensive. The combination of both can increase students' biology literacy skills. However, there are some aspects that can still be improved in the use of ARVi, such as the need for habituation in using augmented reality, so that students do not require a long time to learn the technology. Additionally, the scientific articles on ARVi lack empty spaces (negative areas), making the display appear more crowded. This can be addressed by improving content to add empty spaces and make the display more appealing.

The integration of AR with literacy is still in its early stages, but there is significant potential for development and innovation in the future. The use of AR media can transform learning from conventional to more modern and interactive. The use of AR media can facilitate teachers in presenting biological objects that cannot be presented in class without having to bring the original object. It is advisable for the Indonesian government to invest more in technology-based learning media so that students and teachers become accustomed to using augmented reality, virtual reality, and other technologies. Improving literacy needs to be done continuously, so it takes time for students to become accustomed to reading long texts to broaden their perspectives. This is a suggestion for using AR-based learning media on other biology materials and upgrading literacy content on these media.

CONCLUSION

The use of the ARVi application can affect students' biological literacy. ARVi is an augmented reality-based app that includes scientific articles to improve all aspects of biological literacy. According to research, using the ARVi application can increase students' biological literacy compared to traditional visual media such as PowerPoint. This can be proven by higher post-test scores than pre-test scores. ARVi can enhance all aspects of biological literacy. The highest improvement occurs sequentially on the nominal, multi-dimensional, structural and functional aspects of biological literacy.

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