International Journal of Evaluation and Research in Education (IJERE)
Vol. 14, No. 1, February 2025, pp. 612~620
ISSN: 2252-8822, DOI: 10.11591/ijere.v14i1.31293

A new protist literacy assessment for university students

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Article Info

Article history:

Received May 3, 2024
Revised Aug 23, 2024
Accepted Sep 6, 2024

Keywords:

New protist literacy assessment
Protist course
Protist education
Protist literacy
University students

ABSTRACT

Protists are organisms that have close involvement with student life, especially in maintaining the balance of ecosystems on earth. Literacy instruments about protists are important to develop because students need to know the relationship between protists and life. This instrument was developed because there is no specific instrument to measure student protist literacy. The purpose of this study is to develop a new protist literacy assessment (N-PLA) for university students. The N-PLA development process consists of three stages, namely, i) dimension development, item development, and expert validation; ii) exploratory factor analysis (EFA), content validity, and data reduction; iii) internal consistency through confirmatory factor analysis (CFA). The results of the study found seven dimensions of protist literacy with a total of 36 items: conceptual knowledge (CnK) (7 item), relation information (RlI) (6 item), fact evaluation (FcE) (5 item), real solution (RlS) (5 item), argument identification (ArI) (3 item), self-confidence (S-C) (4 item), and scientific value (ScV) (6 item). The developed N-PLA has a relationship between dimensions and items based on EFA and CFA test results. N-PLA has two types of instruments, namely by using tests and questionnaires to be able to measure the cognitive and affective of students. N-PLA is recommended as a measuring tool that can measure the protist literacy of university students. The results of measuring student's protist literacy become a reference in empowering students protist literacy in the learning process in university.

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1. INTRODUCTION

Protists have an important role in the ecosystem on earth and the survival of various living things. Protists are important contributors to nutrient cycling, energy transfer, and the overall functioning of ecosystems [1]. Heterotrophic protists are more diverse and abundant than phototrophic protists which can regulate the balance of ecosystems on earth [2]. Protists that live in moist soil areas symbiotically with other microbes form microbial communities that can fertilize the soil [3]. The diversity of earth-dwelling protists contributes to students' understanding of the interconnectedness of protists to everyday life.

Protist learning in the scope of biology has challenges related to the characteristics of protist material. There is still some protist material content that is abstract, so it seems irrelevant to student life [4]. Students find difficulties in subsections of the concept of protists such as characteristics, classification, and providing examples of the relationship of protists with the human environment [5]. Students have difficulty distinguishing between protists, bacteria, and viruses [6]. Students do not yet know the role of protists in real life thoroughly [7]. Scientific literacy in protist learning is important to improve during the learning process [8].

Protist literacy is developed through the concept of scientific literacy that can accommodate students' knowledge about protist and the application of the protist concept in everyday life. Protist literacy is an individual's ability to understand, analyze, and apply the concept of protist in a real-life context [9]. Protist diversity is a new challenge in the field of biology to be explored further [10]. Most biology students do not yet understand the role of protists in their lives [11]. Protists studied by students are limited to taxonomic concepts that can be read in textbooks [5]. Protist material is important and must be understood by students its role in human life [12], [13].

Protist literacy is important for students to understand the issues of protist organisms in human life. Understanding protist organisms is essential for the future survival of humans [14]. Protist literacy promotes an understanding of various protist organisms and issues related to protist organisms. For example, understanding the relationship between protists and their environment requires extensive knowledge of protists [15]–[17]. Analysis and investigation of the concept of protist literacy make it easier for students to communicate about various environmental problems caused by protist organisms [9].

Protist literacy has not been developed in protist learning at universities. Students have difficulty understanding the concept of protists learned in the protist class [7]. Protist organisms that are very microscopic make it difficult for students to observe protist organisms [11]. Students can only see the pictures presented by the lecturers, as well as the very dense protist content [18]. The content of protist contains a lot of Latin, while the object being studied cannot be observed without using tools such as a microscope [19]. Students are required to memorize more than to see the objects directly. Therefore, student protist literacy is important to assess.

Search results in various literature databases have not yet developed the protist literacy instrument. Several instruments that have been developed so far are related to protist literacy, namely the quantitative assessment of socio-scientific reasoning (QuASSR) in universities to measure student science literacy [20]. Development of science literacy instruments for high school students [21]. Development of biological literacy instruments based on biological concepts and competencies in junior high school students [22]. So far, no specific literacy instrument has been developed for protist learning.

The development of Protista literacy measurement is recommended to measure student protist literacy. Measurement of protist literacy is not limited to plant-like protists, fungi-like protists, and animal-like protists. This measurement is based on the concept of science literacy which assesses knowledge, cognitive skills, and attitudes [23]. Therefore, this study aimed to develop a protist literacy instrument for university students.

2. METHOD

2.1. Research framework

The process of developing and validating the protist literacy instrument consists of knowledge of protists, cognitive skills, and attitudes. The development of protist literacy instrument goes through several stages of development which refer to various studies on instrument development; i) dimension development, item development, and expert validation; ii) exploratory factor analysis (EFA), content validity, and data reduction; and iii) internal consistency through confirmatory factor analysis (CFA) [24], [25]. The instrument developed is the new protist literacy assessment (N-PLA) which has the potential to measure student protist literacy.

2.2. Participant

Participants in this study were 349 biology education students from several universities in Indonesia. This number of participants has qualified to conduct factor analysis studies. The minimum number of respondents who meet the factor analysis requirements is 150 respondents [26]. The identification results of respondents were women 74.50% (n=260), and men 25.50% (n=89). Data from 349 respondents were analyzed descriptively, EFA and CFA. Student characteristics are students who have gone through Protista material during the learning process in higher education. Students are mapped from various major islands in Indonesia. Respondents from Java Island 38.96% (n=136), Kalimantan Island 11.74% (n=41), Sulawesi Island 28.93% (n=101), and Sumatra Island 20.34% (n=71).

2.3. Dimension development, items, and expert validation

The first step in developing a Protista literacy instrument is the development of dimensions, items, and expert validation. The development of the protist literacy instrument began with focus group discussion (FGD) activities. The FGD was conducted by a team of researchers along with experts in the field of education and protist experts at Universitas Negeri Malang. The FGD aims to obtain their opinions and responses to items developed based on the Protista literacy dimension which will be used as a basis in assessing students' protist literacy. The protist literacy dimension consists of seven dimensions and each

dimension is formed by several question items or statements. Next, we surveyed university students to see how important the seven dimensions of protist literacy were in protist learning.

The dimensions of protist literacy used in this study are i) conceptual knowledge (CnK); ii) relation information (RlI); iii) fact evaluation (FcE); iv) real solution (RlS); v) argument identification (ArI); vi) self-confidence (S-C); and vii) scientific value (ScV) [9]. The creation of question items and statements of protist literacy instruments comes from seven dimensions and is validated by experts in the field of biology education and protist so that the dimensions and the items developed have harmony. Expert validators in the field of biology education have experience in developing instruments in the field of biology and have experience in teaching educational evaluation courses. Expert validators on protist materials have research experience in the field of protist and teach protist materials in universities. The validation was carried out for one month, and the research team met with validators to discuss input and suggestions for validation results. Researchers review and revise according to the results of discussions with expert validation.

2.4. Exploratory factor analysis, content validity, and data reduction

Descriptive analysis is used to identify valid items so that it becomes the basis for conducting further tests with EFA. EFA testing is intended to reduce items with similar or vague statements. There are data requirements for the EFA test, namely first carried out the Kaiser-Meyer-Olkin (KMO) test with a measure of sampling adequacy (MSA) value of >0.5 and Bartlett's test <0.05. EFA testing is done by looking at the value of the factor loading, if the factor loading value is <0.3 then the item is deleted [27].

2.5. Internal consistency with confirmatory factor analysis

Confirmatory factor analysis calculations are used to ensure the accuracy of the dimensions formed from EFA results [28], [29]. The data used includes standardized root mean square residual (SRMR), comparative fit index (CFI), Tucker–Lewis's index (TLI), normed fit index (NFI), and goodness of fit index (GFI). Cronbach's alpha and average variance extract (AVE) are also used to ensure that the item is internally consistent. Criteria used for SRMR≤0.08. CFI, TLI, NFI, and GFI, if it has a value of ≥0.9, are considered good, and ≥0.08 is acceptable [26].

3. RESULTS

Item development is based on the seven dimensions of protist literacy. Protista literacy instruments are divided into two types of instruments, namely test-shaped instruments to measure indicators: CnK, RlI, FcE, RlS, ArI and questionnaires to measure dimensions: S-C and ScV. We create items that are validated by experts so that between dimensions and items are aligned. During the validation process by experts, several aspects need to be improved such as narrative, protist content, use of terms in biology, less operational sentence structure, and nomenclature writing of protist organisms. The revised items are 2, 6, 8, 12, 16, 18, 20, 21, 23, 28, 30, 35, 37, 38, 39, 41, 42, 45. Experts revalidate revised items. The revised statement is then used to test the validity of the content and reduce the data. These results show that there are 45 items of questions and statements spread across all seven dimensions of protist literacy. The average validity result of expert validation is 94.58%. Examples of item development outcomes based on the seven dimensions of protist literacy are shown in Table 1.

The results of descriptive statistical analysis as shown in Table 2, show that the standard deviation (SD) did not exceed 2.5 SD from the mean and the Pearson correlation value was significant and positive (p-value<0.05). The average value of the item ranged from 0.275-4.393 with an SD of 0.449-0.492 The Pearson correlation coefficient (r) ranged from 0.167-0.961, with a significance level of <0.05. The Pearson correlation coefficient is a type of correlation test used to determine the degree of relationship between the score of an individual item and the total score. Referring to the value, it can be said that the value of the coefficient ranges from "the correlation is large enough or strong enough" to "the correlation is very large or very strong". As a result, all items in this instrument can be used as a basis for conducting EFA tests.

Exploratory factor analysis test results as seen in Table 3, show that the MSA value in the KMO test is in the "very good" category (N-PLA (test) 0.888, N-PLA (questionnaire)). The data meet the requirements for the EFA test, as indicated by the Bartlett test score <0.001. The EFA test produces five dimensions in N-PLA (test) and two dimensions in N-PLA (questionnaire). There are 9 items with a loadings factor value of <0.3 (1, 9, 12, 25, 36, 40, 41, 42, 43), remaining 36 items.

Confirmatory factor analysis results with five dimensions on N-PLA (test) as shown in Figure 1, show good statistical value. CFI value=0.954 (good), NFI=0.941 (good), TLI=0.948 (good), GFI=0.826 (acceptable), SRMR=0.026 (good). The results of CFA with two dimensions on N-PLA (questionnaire) as shown in Figure 2 also show good statistical value. CFI value=0.886 (acceptable), NFI=0.884 (acceptable), TLI=0.849 (acceptable), GFI=0.847 (acceptable), SRMR=0.004 (good).

Table 1. N-PLA dimensions and items

No.	Dimension	Examples of items	Item
1.	CnK	A special characteristic of algae not found in higher plants is that they have … A. Pyrenoids B. Chloroplasts C. Cell wall D. Pigmen E. Rhizome	3
2.	RlI	Sailors have a myth that the glowing sea is a sign of the existence of a dragon or God. But apparently, the luminous sea event is a natural phenomenon caused by plant-like protists of the division Pyrrophyta. These events are …. A. Bioluminescence caused by the oxidation process of luciferin by the luciferase enzyme when ATP and H_2O are present B. Bioluminescence caused by the oxidation process of luciferase by the enzyme luciferin when ATP and oxygen are present C. Bioluminescence caused by the oxidation process of luciferase by the enzyme luciferin when oxygen and H_2O are present D. Bioluminescence caused by the oxidation process of luciferase by the enzyme luciferin when ATP and H_2O are present E. Bioluminescence caused by the oxidation process of luciferin by the luciferase enzyme when ATP and oxygen are present	16
3	FcE	Acetospores are a relatively small phylum consisting of extracellular obligate parasites characterized by spores that lack polar caps or polar filaments. Why is it called *an obligate parasite*? A. Because it lives in the host's body from the initial phase of life to adulthood. B. Because his life depends on his host. C. Because it carries the disease in the host's body. D. Because it can live independently under normal circumstances. E. Because it coincidentally lodges in the body of an unwanted host.	26
4	RlS	A woman experienced pain in the abdomen and based on the doctor's diagnosis found parasites in the intestine, namely *Balantidium coli*. What are the solutions to prevent the disease? A. Wash hands with running water, because *Balantidium coli* can develop bik in running water. B. Using *hand sanitizer*, because it helps *Balantidium coli* in producing proteolytic enzymes. C. Giving antibiotics, because *Balantidium coli* dies when given antibiotics. D. Washing food that has been contaminated, because *Balantidium coli* has the potential to eat other microorganisms in food. E. Consume plenty of water, as *Balantidium coli* forms cysts when stool is dehydrated in the colon.	14
5	ArI	Blooming algae is another term for algae explosion. The algae explosion itself is an event or condition where a body of water, both ponds, lakes, and swamps experience a large enough plankton population explosion. Ponds with a very green color are caused by an explosion in green algae populations due to excessive feeding of fish. This resulted in … A. algae produce excessive green pigment that makes the pool water green B. moss around the pond grows and algae consume moss around the pond so that green algae are more abundant C. fish become dead and green algae become more numerous, resulting in the pond becoming green D. nutrition for algae is excessive so that their breeding becomes very uncontrollable E. water reacts with fish feed so that it turns green, and green algae grow on green water	23
6	S-C	All the questions that arise in me about Protista have one correct answer.	32
7	ScV	Protist material is very useful in everyday life.	45

Table 2. The results of descriptive statistical analysis

Item	Mean	SD	r	Item	Mean	SD	r
1	0.553	0.498	0.425**	24	0.413	0.493	0.607**
2	0.438	0.497	0.391**	25	0.567	0.496	0.175*
3	0.427	0.495	0.628**	26	0.484	0.500	0.467**
4	0.344	0.476	0.624**	27	0.347	0.477	0.613**
5	0.430	0.496	0.613**	28	0.287	0.453	0.629**
6	0.275	0.447	0.647**	29	0.510	0.501	0.419*
7	0.424	0.495	0.628**	30	0.372	0.484	0.613*
8	0.481	0.500	0.464**	31	3.384	1.417	0.952**
9	0.324	0.469	0.307*	32	3.410	1.490	0.925**
10	0.289	0.454	0.399**	33	3.393	1.413	0.955**
11	0.367	0.483	0.267*	34	3.381	1.415	0.951**
12	0.344	0.465	0.399**	35	3.347	1.494	0.896**
13	0.304	0.461	0.384**	36	4.393	0.650	0.167*
14	0.421	0.494	0.629**	37	3.390	1.411	0.954**
15	0.301	0.459	0.380**	38	3.410	1.490	0.925**
16	0.341	0.475	0.619**	39	3.407	1.416	0.960**
17	0.490	0.501	0.469**	40	3.100	1.448	0.845**
18	0.281	0.450	0.640**	41	3.284	1.272	0.826**
19	0.352	0.478	0.608**	42	3.447	1.472	0.841**
20	0.436	0.497	0.622**	43	3.324	1.303	0.840**
21	0.350	0.478	0.617**	44	3.413	1.492	0.925**
22	0.450	0.495	0.582**	45	3.410	1.419	0.961**
23	0.278	0.449	0.642**				

*<0.05, **<0.01

The final stage is internal consistency analysis as presented in Table 4. Researchers measure internal consistency to explain the consistency of instruments that have been made. The values of Cronbach's alpha coefficient and AVE are used to see the internal consistency. Cronbach's alpha value meets the >0.06 criterion, and the AVE value meets the >0.05 criterion. All dimensions/items have internal consistency, so they are feasible to apply.

Table 3. The results of EFA N-PLA

Instrument type	Dimensions	Item	Factor loadings
N-PLA (test)	CnK	Item_3	0.975
		Item_14	0.974
		Item_7	0.962
		Item_5	0.954
		Item_24	0.947
		Item_20	0.946
		Item_22	0.916
	RlI	Item_4	0.981
		Item_16	0.977
		Item_21	0.976
		Item_27	0.972
		Item_19	0.966
		Item_30	0.927
	FcE	Item_8	0.973
		Item_26	0.972
		Item_17	0.963
		Item_29	0.928
		Item_11	0.454
	RlS	Item_23	0.964
		Item_6	0.964
		Item_18	0.954
		Item_28	0.945
		Item_2	0.462
	ArI	Item_10	0.957
		Item_13	0.941
		Item_15	0.930
N-PLA (questionnaire)	S-C	Item_32	0.925
		Item_44	0.925
		Item_38	0.925
		Item_35	0.884
	ScV	Item_33	0.847
		Item_37	0.847
		Item_31	0.845
		Item_34	0.845
		Item_39	0.843
		Item_45	0.843

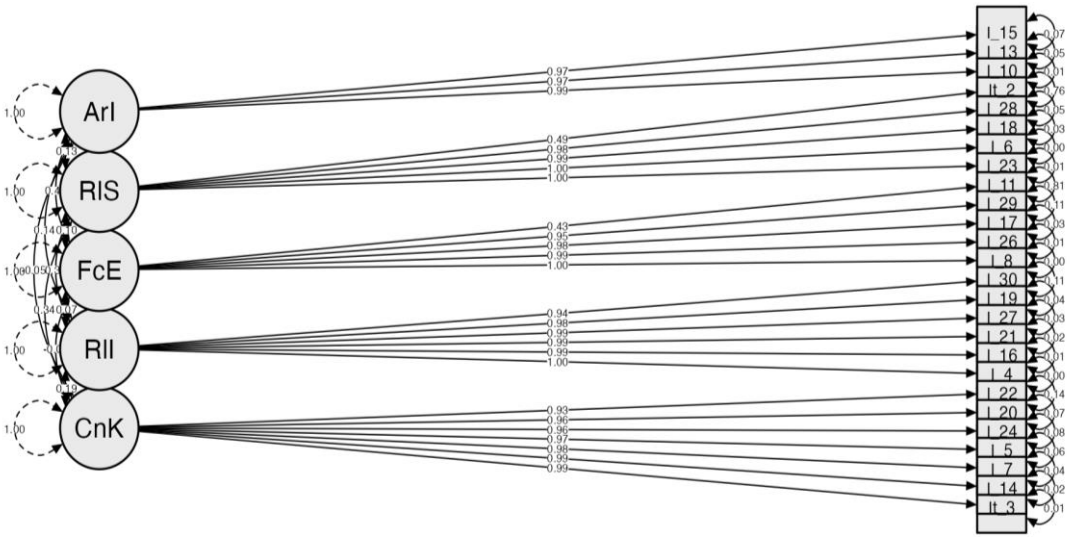

Figure 1. The results of CFA N-PLA (test)

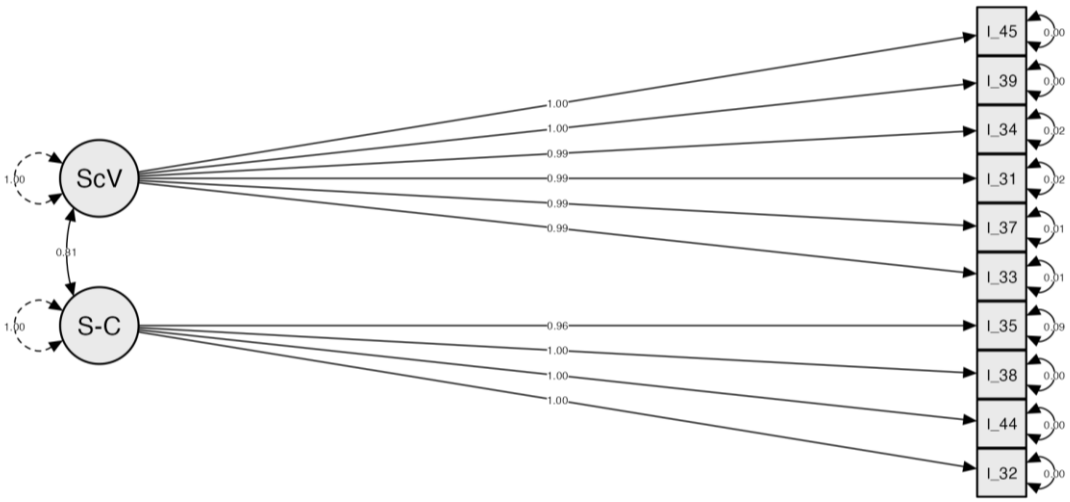

Figure 2. The results of CFA N-PLA (questionnaire)

Table 4. Internal consistency results of N-PLA

Dimension	α	AVE
CnK	0.991	0.940
RlI	0.994	0.965
FcE	0.939	0.817
RlS	0.942	0.805
ArI	0.984	0.955
S-C	0.994	0.978
ScV	0.998	0.988

4. DISCUSSION

This research was conducted to develop and validate N-PLA to measure the protist literacy students in Indonesia or even other countries that have similar characteristics to Indonesian students. N-PLA was developed through a long process ranging from dimensional and item determination and statistical analysis to see the validity and reliability of instruments. Protista literacy for students is very important because of the realization of protist learning and sustainable development. Protist organisms have an important role in sustainable development [14]. Protist literacy is the basis for building student knowledge about protist organisms in human life.

The researchers were able to confirm that N-PLA can make a significant contribution to assessing students' protist literacy. The importance of understanding the protist organism as an effort to achieve the target of protist education [4]. The role of protists in biology learning deserves special attention. The use of protists in the classroom as model organisms is very helpful in studying other biological sciences. Protists can represent higher organisms as the basis of biology, such as physiology, ecology, taxonomy, and evolution [30]. The use of protist organisms in biology learning makes it easy for students to observe various contexts of biological phenomena.

N-PLA validity and reliability testing using EFA and CFA tests. The results of the analysis show that the instrument is valid and internally consistent. N-PLA is developed based on seven dimensions of protist literacy. The first dimension, CnK is defined as understanding the concept of protist organisms. Knowledge of protists or basic concepts of protists is first introduced by students [31]. The statement items in this dimension include some understanding of Protista, the characteristics of the organism Protista, and everything related to the concept of protist. The knowledge gained is the result of various information that has been analyzed and understood [32]. The second dimension, RlI means the process of combining various information to understand problems in protist organisms. Information obtained related to protist organisms is very much in human life, such as various species of protists that live in the human digestive tract [33]. Question items in this dimension are information about algae population explosions and bioluminescence events. Interconnected information has the potential to develop solutions to various existing problems [34].

The third dimension, FcE is defined as evaluating scientific facts related to protist organisms. The item in question relates to the phenomenon of protists as parasites and diseases caused by protist organisms. Phenomena related to protist organisms are facts that must be checked for truth. Scientific facts are observations that have been confirmed repeatedly so that they can be accepted as true [35]. The fourth

dimension, RlS is defined as the selection of the right solution to overcome the problems caused by protist organisms. Question items are in the form of discourse on problems presented related to Protista, as well as some potential solutions to solve these problems. A good solution is found collaboratively, and the suitability of the information obtained [36]. The fifth dimension, ArI means identifying scientific arguments about protists. Question items relate to several scientific arguments and why they were chosen. Scientific argumentation is a tool for students in thinking [37]. Science issues can be applied in the learning process in the classroom to train students' scientific arguments [38].

The sixth and seventh dimensions belong to the affective domain. The sixth dimension, S-C is defined as students' confidence in learning protist. The statement item presented is a psychological statement that seeks to see students' confidence in the protist material obtained in the protist class. Student learning outcomes can be improved by having optimal confidence in learning [39]. The seventh dimension is ScV which means the scientific values that can be obtained when studying protist. The statement item relates to the usefulness of the protist organism after it has been studied in the classroom. Students use their reasoning based on appropriate scientific concepts [40].

5. CONCLUSION

The new protist literacy assessment is based on the seven dimensions of protist literacy with a total of 36 items; CnK (7 items), RlI (6 items), FcE (5 items), RlS (5 items), ArI (3 items), S-C (4 items), and ScV (6 items). EFA and CFA analysis is used to see the relationship between dimensions and items developed. All items are internally consistent, so they have the potential to describe students' protist literacy. This instrument is significantly useful in measuring the literacy aspects of student protests in protist learning in higher education. The development of N-PLA has implications that can measure protist literacy students in Indonesia. This research is the latest research on the development of N-PLA. Future researchers can use this research as a reference in developing instruments on literacy. Other researchers can also use innovative learning models in the Protista course whose results can be assessed with N-PLA. Researchers can then make innovations on N-PLA through the development of education, time, and science. This study has limitations during the research conducted, namely, the condition of students when working on N-PLA cannot be controlled by researchers because only researchers share it through an online platform. Further research is expected to be able to control the condition of students when working on instruments.

ACKNOWLEDGEMENTS

Thank you to all students who have volunteered to assist researchers in collecting research data. The authors would also like to thank validators who have examined the feasibility of this research instrument very carefully. We express our gratitude to the Directorate of Research, Technology and Community Service (DRTPM), Ministry of Education, Culture, Research and Technology, Indonesia under Grant 140/E5/PG.02.00.PL/2023 & 20.6.23/UN32.20.1/LT/2023 who have funded this research.

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