Exploring Protist Literacy Among University Students': Findings from a Recent Survey

Hardianto Hardianto, Susriyati Mahanal*, Hendra Susanto, and Sitoresmi Prabaningtyas

Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Malang, Indonesia
*susriyati.mahanal.fmipa@um.ac.id

Abstract. Students have difficulty in associating Protist organisms in their daily lives. Protist literacy is needed so that students can apply the concept of Protista in the real world. The purpose of this study is to find out the level of students' Protist literacy. This study is survey research using a sample of 349 students in Indonesia. Sampling technique by accidental sampling. Data was collected using the Protista literacy instrument consisting of a multiple-choice test and a questionnaire based on the Protista literacy dimension, namely 1) conceptual knowledge, 2) relation information, 3) fact evaluation, 4) real solution, 5) argument identification, 6) self-confidence, and 7) scientific value. The findings show that student Protista literacy is still very low (M=45.99). Efforts to improve student protist literacy are by integrating problem-based learning with technology. Developing various learning innovations in Protista learning is expected to empower students' Protist literacy.

Keywords: Protist Literacy, Protist Course, University Students.

1 Introduction

Protist learning requires 21st-century skills in the learning process in higher education. Protist content has its characteristics, so it is important to develop 21st-century skills in Protist learning [1]. The characteristics of Protist matter are, 1) the matter is abstract, 2) most of the objects studied are microscopic, or cannot be observed directly, and 3) Protist organisms are often found in daily life [2]. The 21st-century skills needed in learning Protista are science literacy skills [3].

Science literacy develops students' ability to interpret data in various formats, scientific reasoning, and the relationship between science, technology, society, and the environment [4]. Students who have good science literacy skills can ask high-quality research questions, formulate scientifically tested hypotheses, and design an experiment [5]. The development of science and technology is greatly influenced by students' science literacy skills as a pillar of scientific community development [6].

T. A. Aziz et al. (eds.), *Proceedings of the 4th Science and Mathematics International Conference (SMIC 2024)*, Advances in Physics Research 11,
https://doi.org/10.2991/978-94-6463-624-6_18

The results of research in several countries and regions in Indonesia concluded that student science literacy is in the low category. The results of student science literacy research in Taiwan show that the average score of 19.08 is in the low category [7]. The level of science literacy of students in Thailand with an average score of 52 and Indonesia of 47 is in the low category [8]. Several research results identified the level of student science literacy in various regions in Indonesia such as the city of Merauke, South Papua with a score of 38.26 in the low category [9], Pekanbaru, Riau 29.92 low category [10], and Malang, East Java with a score of 58.31 in the medium category [11]. Science literacy has the potential to be developed in Protist learning [3].

Protist materials in universities consist of plant-like Protists, animal-like Protists, and fungus-like Protists. All eukaryotic organisms other than animals, plants, and fungi are called Protist organisms [12]. Protists represent a very diverse paraphyletic unicellular eukaryotic group, which includes most of the eukaryotic phylogenetic diversity [13]. Metagenetic studies using environmental deoxyribonucleic acid (eDNA) reveal a very wide diversity of Protist lineages [14].

Emphasizing the value and potential of knowledge about Protists, the concept of Protist literacy is introduced. Protist literacy underlies an understanding of the issues of Protist organisms in daily life [15]. Protist literacy dimensions are conceptual knowledge, relation information, fact evaluation, real solution, argument identification, self-confidence, and scientific value. Understanding Protist organisms is essential for the future survival of humans [16]. Various studies on issues of Protist organisms related to human life. Extraction of astaxanthin from an algae species, namely *Haematococcus pluvalis* as an anti-cancer agent in lung cancer cells [17]. Research on algae-based wastewater treatment systems [18]. Protists can act as bioindicators of soil quality and play a role in plant productivity [19].

Students have difficulty understanding the concept of Protists learned in the Protist class [20]. Highly microscopic Protist organisms make it difficult for students to observe Protist organisms [21]. Students can only see the pictures the lecturers presented and the very dense Protist content[22]. Protist content contains a lot of Latin, while the object studied cannot be observed without using tools such as microscopes [23]. Students are required to memorize more than to see the objects directly. The study of Protist literacy is necessary for students' initial overview of Protist organisms. Therefore, this study aims to explore students' Protist literacy.

2 Methods

This study is a survey research for the exploration of student Protista literacy. The research sample consisted of 349 undergraduate students in biology and biology education spread across various regions in Indonesia. Sampling technique using an accidental sampling technique. The instruments used were multiple-choice test instruments and questionnaires totaling 36 items. The instruments are arranged based on the dimensions of Protista literacy, namely, 1) conceptual knowledge, 2) relation information, 3) fact evaluation, 4) real solution, 5) argument identification, 6) self-confidence, and 7) scientific value [15]. A multiple-choice test measures dimensions 1-5, and dimensions 6-7 are measured by a questionnaire.

The instruments used are valid (r=0.167-0.961, and p-level <0.05) and reliable (*a*=0.939-0.998) based on the results of field trials. Data was obtained from the results of filling in the student for the instrument shared through Google Form. The data was analyzed with descriptive statistics in the form of the average value of each dimension, and the average total value of students' Protist literacy. The criteria for the level of students' Protist literacy are based on the science literacy criteria described in **Table 1**.

Table 1. Protist literacy criteria

No.	Value	Information
1	86 ≥	Very high
2	76 - < 86	High
3	60 - < 76	Medium
4	55 - < 60	Low
5	< 55	Very low

Source: [24]

3 RESULT AND DISCUSSION

The description of the data on the level of students' Protist literacy shows that the average total of students' Protist literacy is in the very low category (M=45.99). The details of the values in each dimension are, conceptual knowledge (M=41.30) is in the very low category, relation information (M=35.15) is in the very low category, fact evaluation (M=36.68) is in the very low category, real solution (M=37.31) is in the very low category, argument identification (M=37.25) is in the very low category, self-confidence (M=67.66) is in the medium category, scientific value (M=66.57) is in the medium category (**Figure 1).**

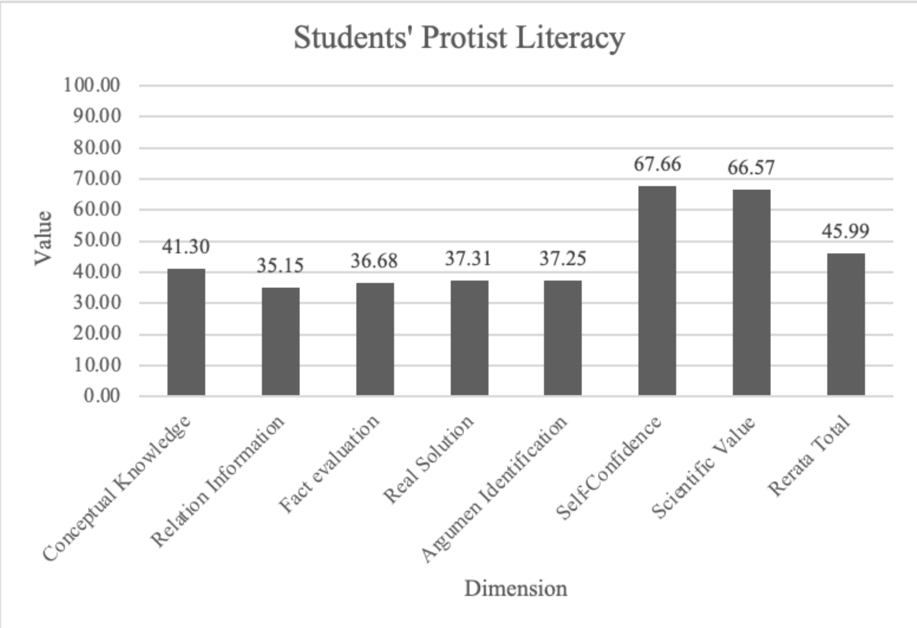

Fig. 1. Profile of students' Protist literacy throughout Indonesia

The conceptual knowledge dimension is in the very low category, meaning that students have inadequate knowledge of the concept of Protist knowledge [25], [26]. Students must understand and recognize the diversity and classification of the Protista concept. Students must know the core concepts related to the role of Protists in daily life. Conceptual knowledge refers to thinking activities such as remembering, analyzing, and understanding [27]. Conceptual knowledge means connecting various existing information. The quality of knowledge refers to the way something is known and how well it can be understood. Conceptual knowledge will refer to principles and definitions.

The dimension of relation information is in the very low category which shows that students are still unable to connect information/data to understand the problems of Protist organisms in human life. The problems associated with Protist organisms are numerous in human life such as colonization of Protists can lead to variations in the microbiota in the human intestine [28]. Several studies have shown that there is a complex reciprocity between fungi, Protists, and other microbiota in the human gut. The relationship between various information becomes a solution in solving or dealing with complex problems [29]. Student experience in connecting the information obtained is important to be developed in the diagnosis of student learning difficulties. The correlational approach used in this dimension begins by describing a phenomenon that has been experienced. Individuals who can connect new information have the potential to develop ideas to solve complex problems [30].

The fact evaluation dimension is in the very low category which shows that students are still lacking in evaluating scientific facts about Protists. The issue of Protist organisms in the community is important to be evaluated for its truth. Scientific facts are observations that have been repeatedly confirmed [31]. Repeated confirmation can be in the form of direct observation or conclusions that can be used as a reference to determine scientific facts [32]. Truth in science is never final. Something that is accepted today can be modified or even rejected later. The importance of fact evaluation about Protists is to obtain scientific truth from Protist-related information from various sources of information.

The real solution dimension is in the very low category, which means that students are still lacking in choosing the right solution related to the problem of human interaction with important organisms to be used as a dimension of Protist literacy. The phenomenon that is currently developing is nanoparticles produced by industry that cause environmental toxicity [33]. Ciled protists have been extensively studied by ecotoxicologists, due to the role of such Protist organisms in microbial regulation to overcome environmental toxicity [34]. The selection of solutions to overcome environmental problems related to Protist organisms has been carried out a lot. Students in the learning process as problem solvers to find good solutions in making students independent learners [35]. A good solution discovery process is for students to find relevant information and collaborate with other students to develop solutions [36].

The fifth dimension of argument identification is in the very low category, which means that students need more practice to identify valid arguments. Scientific argumentation skills help students in reasoning [37]. Argumentation as a tool in the process of scientific explanation in the classroom [38], [39]. The development of argumentation skills can be trained by the preparation of socio-scientific issues in the learning process [40]. Scientific arguments about Protists such as, Algae are eukaryotic, unicellular, or multicellular organisms, but they do not have special organs and tissues, and do not have vascularization. The essence of a scientific argument is to make a statement that is supported by scientific evidence. Scientific argumentation aims to find a relationship between ideas and scientific evidence [41]. Students must have the ability to understand and apply theories, principles, laws, or models to be involved in scientific arguments in the learning process.

The sixth dimension of self-confidence is in the medium category, which means that students are still not confident in expressing opinions about Protist organisms. Students have a lot of time to learn facts about Protist organisms so that they can present them in the Protist class. Protists have a lot of abstract content, so it is necessary to train students to read more and be confident in conveying the concept of Protists [2]. Students increase their confidence by listening to and commenting on other students' ideas. The interest of students who play an active role in learning can be further increased because there is confidence in expressing opinions in the classroom [42].

The seventh dimension, namely scientific value, is in the medium category, which means that the understanding of scientific values must still be emphasized in the literacy dimension of Protista. Scientific values are scientific values contained in a scientific concept [43]. Students use their intellect to understand something by not believing in myths that exist in the community. All problems are considered with common sense and solved through the process of thinking. A case that often arises related to Protist organisms is a colorful marine phenomenon called bioluminescence [44], [45]. Bioluminescence is the light produced by algae that live in the ocean through chemical processes [46]. The aspect of the benefits of science for human life is also part of the values of science. An example that is often obtained in learning Protist is the use of *Chlorella* sp. as a dietary supplement that can increase immunity [47].

Empowerment of Protist literacy in learning makes students able to recognize the use of Protist organisms in daily life. Protist literacy supports the understanding of Protist organisms and issues related to human life/the surrounding environment such as algae blooms in waters [48], [49], and *Plasmodium* sp. causes of malaria in humans [50]. Protist literacy makes it easier for students to understand Protista as an important aspect of daily life. Knowledge of Protist issues is useful in sustainable development such as biofuels from algae as fuel in the future [51]. Students will be more directed in learning Protist if equipped with a problem-based learning model that is integrated with technology.

Potential efforts to improve Protist literacy by forming problem-based learning with technology. Problem-based learning makes students able to explain phenomena scientifically [52]. Students are also more directed in learning Protist if it is equipped with e-learning [53]. The integration of problem-based learning with blended learning has the opportunity to optimize abstract content [54].

4 CONCLUSION

The results show that the level of students' Protist literacy in various regions in Indonesia is still very low. Low Protist literacy is caused by students not understanding issues related to Protist organisms in human life. Problem-based learning integrated with technology can be applied in Protist learning to empower students' Protist literacy. The limitation of the research is the difference in students' initial understanding of Protists that cannot be controlled by the researcher. Future research recommends that it is hoped that there will be learning innovations that can empower students' Protist literacy in Protist learning in higher education.

Acknowledgments. We would like to thank 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) for funding this research.

Disclosure of Interests. This research has no conflict of interest

References

[1] D. Aulia and M. Khalid Riefani, "Google Site as a learning media in the 21st Century on the Protista concept," *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, vol. 3, no. 3, pp. 173–178, 2021, [Online]. Available: https://ppjp.ulm.ac.id/journal/index.php/bino

[2] D. Raharjo, M. Ramli, and Y. Rinanto, "Misconception protist in high school biology textbooks," in *International Conference on Mathematics and Science education*, 2018, pp. 85–90. [Online]. Available: http://science.conference.upi.edu/proceeding/index.php/ICMScE/issue/view/3%7CICMScE2018

[3] S. Mahanal, S. Zubaidah, and D. Setiawan, "The Potential of RICOSRE to Enhance University Students' Science Literacy in Biology," in *International Conference on Biology, Sciences and Education (ICoBioSE 2019)*, 2020, pp. 282–287. doi: 10.2991/absr.k.200807.056.

[4] X. Xuan, Q. Jin, I. Jo, Y. Duan, and M. Kim, "The Potential Contribution of Geography Curriculum to Scientific Literacy," *Journal of Geography*, vol. 118, no. 5, pp. 185–196, 2019, doi: 10.1080/00221341.2019.1611906.

[5] M. P. Virtič, "Teaching science & technology: components of scientific literacy and insight into the steps of research," *Int J Sci Educ*, vol. 44, no. 12, pp. 1916–1931, 2022, doi: 10.1080/09500693.2022.2105414.

[6] Y. D. Asworo, "How important does chemistry and literacy? bibliometric analysis from 1993–2023," *J. Res. Env. Sci. Educ.* vol. 1, no. 1, pp. 42–57, 2024. https://doi.org/10.70232/eskbj934.

[7] C. T. Wen *et al.*, "Students' guided inquiry with simulation and its relation to school science achievement and scientific literacy," *Comput Educ*, vol. 149, no. September 2019, p. 103830, 2020, doi: 10.1016/j.compedu.2020.103830.

[8] R. A. Z. El Islami and P. Nuangchalerm, "Comparative study of scientific literacy: Indonesian and thai pre-service science teachers report," *International Journal of Evaluation and Research in Education*, vol. 9, no. 2, pp. 261–268, 2020, doi: 10.11591/ijere.v9i2.20355.

[9] N. B. Sumanik, E. Nurvitasari, and L. F. Siregar, "Analysis of science literation Abilities profile prospective teachers of chemical education," *Quantum: Jurnal Inovasi Pendidikan Sains*, vol. 12, no. 1, pp. 22–32, 2021, doi: 10.20527/quantum.v12i1.10215.

[10] M. Berlian, I. M. Mujtahid, R. Vebrianto, and M. Thahir, "Profil literasi sains dalam pembelajaran IPA di era covid-19: Studi kasus di Universitas Terbuka," *Journal of Natural Science and Integration*, vol. 4, no. 1, p. 77, 2021, doi: 10.24014/jnsi.v4i1.11662.

[11] A. Muslihasari, H. Susilo, I. Ibrohim, and B. Lukiati, "Profil literasi sains mahasiswa PGSD di Malang," *Primary Education Journals*, vol. 2, no. 2, pp. 137–143, 2022.

[12] J. M. Archibald, A. G. B. Simpson, and C. H. Slamovits, *Handbook of the Protists*. Switzerland: Springer International Publishing, 2017. doi: 10.1007/978-3-319-32669-6.

[13] S. M. Adl *et al.*, "The revised classification of eukaryotes," *Journal of Eukaryotic Microbiology*, vol. 59, no. 5, pp. 429–514, 2012, doi: 10.1111/j.1550-7408.2012.00644.x.

[14] J. Pawlowski, "Protist Evolution and Phylogeny," 2014, *John Wiley and Sons Ltd*. doi: 10.1002/9780470015902.a0001935.pub2.

[15] H. Hardianto, S. Mahanal, H. Susanto, and S. Prabaningtyas, "Protist literacy: A novel concept of protist learning in higher education," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 20, no. 2, p. em2399, Feb. 2024, doi: 10.29333/ejmste/14157.

[16] S. Merlo, X. Gabarrell Durany, A. Pedroso Tonon, and S. Rossi, "Marine microalgae contribution to sustainable development," *Water (Basel)*, vol. 13, no. 10, pp. 1–24, 2021, doi: 10.3390/w13101373.

[17] B. A. Guler, P. Saglam-Metiner, I. Deniz, Z. Demirel, O. Yesil-Celiktas, and E. Imamoglu, "Aligned with sustainable development goals: microwave extraction of astaxanthin from wet algae and selective cytotoxic effect of the extract on lung cancer cells," *Prep Biochem Biotechnol*, vol. 0, no. 0, pp. 1–7, 2022, doi: 10.1080/10826068.2022.2116455.

[18] H. M. K. Delanka-Pedige, S. P. Munasinghe-Arachchige, I. S. A. Abeysiriwardana-Arachchige, Y. Zhang, and N. Nirmalakhandan, "Algal pathway towards meeting United Nation's sustainable development goal 6," *International Journal of Sustainable Development and World Ecology*, vol. 27, no. 8, pp. 678–686, 2020, doi: 10.1080/13504509.2020.1756977.

[19] K. A. Chandarana and N. Amaresan, "Soil protists: An untapped microbial resource of agriculture and environmental importance," *Pedosphere*, vol. 32, no. 1, pp. 184–197, Feb. 2022, doi: 10.1016/S1002-0160(21)60066-8.

[20] J. Van Etten, R. Keddis, J. Lisa, and I. Rauschenbach, "The Diverse World of Protists—an Ideal Community with which to Introduce Microscopy in the Microbiology Teaching Laboratory," *J Microbiol Biol Educ*, vol. 23, no. 1, pp. 23–25, 2022, doi: 10.1128/jmbe.00142-21.

[21] A. S. Kırmızıgül and E. Kızılay, "Investigation of the Pre-service Science Teachers' Perceptions of Protists," *Pedagogical Research*, vol. 5, no. 4, pp. 1–10, 2020, doi: 10.29333/pr/9132.

[22] I. Yunanda, H. Susilo, and A. Ghofur, "Misconceptions identification on biodiversity and protist using multiple choice open reason (mcor)," *Biosfer: jurnal Pendidikan Biologi*, vol. 12, no. 2, pp. 170–181, 2019, doi: 10.21009/biosferjpb.v12n2.170-181.

[23] M. S. G. Sihombing and H. Pranoto, "Analysis of students' learning difficulties in Protist material," *Jurnal Pelita Pendidikan*, vol. 9, no. 3, pp. 143–148, 2021, [Online]. Available: https://jurnal.unimed.ac.id/2012/index.php/pelita/article/view/17301/13178

[24] J. Suroso, Indrawati, Sutarto, and I. Mudakir, "Profile of high school students science literacy in east java," *J Phys Conf Ser*, vol. 1832, no. 1, p. 012040, Mar. 2021, doi: 10.1088/1742-6596/1832/1/012040.

[25] A. Rossi, A. Bellone, S. I. Fokin, V. Boscaro, and C. Vannini, "Detecting Associations Between Ciliated Protists and Prokaryotes with Culture-Independent Single-Cell Microbiomics: a Proof-of-Concept Study," *Microb Ecol*, vol. 78, no. 1, pp. 232–242, 2019, doi: 10.1007/s00248-018-1279-9.

[26] T. Weisse, R. Anderson, H. Arndt, A. Calbet, P. J. Hansen, and D. J. S. Montagnes, "Functional ecology of aquatic phagotrophic protists – Concepts, limitations, and perspectives," *Eur J Protistol*, vol. 55, pp. 50–74, 2016, doi: 10.1016/j.ejop.2016.03.003.

[27] T. Shivolo, "A classroom intervention of enhancing namibian preservice science teachers' conceptual understanding of properties of waves through mnemonics," *J. Res. Math. Sci. Technol. Educ.* vol. 1, no. 2, pp. 62-76, 2024. doi: 10.70232/jrmste.v1i2.9.

[28] O. Partida-Rodríguez *et al.*, "Human Intestinal Microbiota: Interaction Between Parasites and the Host Immune Response," *Arch Med Res*, vol. 48, no. 8, pp. 690–700, 2017, doi: 10.1016/j.arcmed.2017.11.015.

[29] S. Lanning and J. Mallek, "Factors Influencing Information Literacy Competency of College Students," *Journal of Academic Librarianship*, vol. 43, no. 5, pp. 443–450, 2017, doi: 10.1016/j.acalib.2017.07.005.

[30] M. L. Magnuson, "Web 2.0 and Information Literacy Instruction: Aligning Technology with ACRL Standards," *Journal of Academic Librarianship*, vol. 39, no. 3, pp. 244–251, 2013, doi: 10.1016/j.acalib.2013.01.008.

[31] A. K. Dean, N. Ellis, and V. K. Wells, "Science 'fact' and science 'fiction'? Homophilous communication in high-technology B2B selling," *Journal of Marketing Management*, vol. 33, no. 9–10, pp. 764–788, 2017, doi: 10.1080/0267257X.2017.1324895.

[32] G. A. Wolf-Chase, "New worlds, new civilizations? From science fiction to science fact," *Theology and Science*, vol. 16, no. 4, pp. 415–426, 2018, doi: 10.1080/14746700.2018.1525221.

[33] J. A. Vilas-Boas, M. V. X. Senra, and R. J. P. Dias, "Ciliates in ecotoxicological studies: A minireview," *Acta Limnologica Brasiliensia*, vol. 32, 2020, doi: 10.1590/s2179-975x6719.

[34] A. Gomiero, A. Dagnino, C. Nasci, and A. Viarengo, "The use of protozoa in ecotoxicology: Application of multiple endpoint tests of the ciliate E. crassus for the evaluation of sediment quality in coastal marine ecosystems," *Science of the Total Environment*, vol. 442, pp. 534–544, 2013, doi: 10.1016/j.scitotenv.2012.10.023.

[35] A. L. Dent and A. C. Koenka, "The Relation Between Self-Regulated Learning and Academic Achievement Across Childhood and Adolescence: A Meta-Analysis," *Educ Psychol Rev*, vol. 28, no. 3, pp. 425–474, 2016, doi: 10.1007/s10648-015-9320-8.

[36] A. K. Jani and M. Moersilah, "Development of learning cycle 5e practical instructions on acid-base titration using natural ph indicators based on green

chemistry," *J. Comput. Sci. Math. Learn.* vol. 1, no. 2, pp. 93-101. doi: 10.70232/4eagx078.
[37] M. Zhu, H. S. Lee, T. Wang, O. L. Liu, V. Belur, and A. Pallant, "Investigating the impact of automated feedback on students' scientific argumentation," *Int J Sci Educ*, vol. 39, no. 12, pp. 1648–1668, 2017, doi: 10.1080/09500693.2017.1347303.
[38] L. L. Heng, J. Surif, and C. H. Seng, "Malaysian Students' Scientific Argumentation: Do groups perform better than individuals?," *Int J Sci Educ*, vol. 37, no. 3, pp. 505–528, 2015, doi: 10.1080/09500693.2014.995147.
[39] X. Li, W. Wang, and Y. Li, "Systematically reviewing the potential of scientific argumentation to promote multidimensional conceptual change in science education," *Int J Sci Educ*, vol. 44, no. 7, pp. 1165–1185, 2022, doi: 10.1080/09500693.2022.2070787.
[40] L. Ladachart and L. Ladachart, "Preservice biology teachers' decision-making and informal reasoning about culture-based socioscientific issues," *Int J Sci Educ*, vol. 43, no. 5, pp. 641–671, 2021, doi: 10.1080/09500693.2021.1876958.
[41] L. Jones, "Developing deaf children's conceptual understanding and scientific argumentation skills: A literature review," *Deafness and Education International*, vol. 16, no. 3, pp. 146–160, 2014, doi: 10.1179/1557069X13Y.0000000032.
[42] D. A. R. Anggraeni and M. Moersilah, "The influence of green chemistry activities on students' environmental care attitudes," *J. Educ. Sustain. Dev. Stud.* vol. 1, no. 1, pp. 41-50. oi: 10.70232/b8rkjq30.
[43] J. Sickler, T. M. Cherry, L. Allee, R. R. Smyth, and J. Losey, "Scientific Value and Educational Goals: Balancing Priorities and Increasing Adult Engagement in a Citizen Science Project," *Applied Environmental Education and Communication*, vol. 13, no. 2, pp. 109–119, 2014, doi: 10.1080/1533015X.2014.947051.
[44] D. Menghini and S. Aubry, "De novo transcriptome assembly data of the marine bioluminescent dinoflagellate Pyrocystis lunula," *Data Brief*, vol. 37, p. 107254, 2021, doi: 10.1016/j.dib.2021.107254.
[45] L. S. Perin, G. V. Moraes, G. A. Galeazzo, and A. G. Oliveira, "Bioluminescent Dinoflagellates as a Bioassay for Toxicity Assessment," *Int J Mol Sci*, vol. 23, no. 21, pp. 1–14, 2022, doi: 10.3390/ijms232113012.
[46] E. Brodl, A. Winkler, and P. Macheroux, "Molecular Mechanisms of Bacterial Bioluminescence," *Comput Struct Biotechnol J*, vol. 16, pp. 551–564, 2018, doi: 10.1016/j.csbj.2018.11.003.
[47] V. Kotrbáček, J. Doubek, and J. Doucha, "The chlorococcalean alga Chlorella in animal nutrition: a review," *J Appl Phycol*, vol. 27, no. 6, pp. 2173–2180, 2015, doi: 10.1007/s10811-014-0516-y.
[48] A. W. Griffith and C. J. Gobler, "Harmful algal blooms: A climate change costressor in marine and freshwater ecosystems," *Harmful Algae*, vol. 91, no. March 2019, p. 101590, 2020, doi: 10.1016/j.hal.2019.03.008.
[49] W. A. Wurtsbaugh, H. W. Paerl, and W. K. Dodds, "Nutrients, eutrophication and harmful algal blooms along the freshwater to marine continuum," *Wiley*

Interdisciplinary Reviews: Water, vol. 6, no. 5, pp. 1–27, 2019, doi: 10.1002/WAT2.1373.

[50] S. Kumar *et al.*, "A Malaria Parasite Cross Reveals Genetic Determinants of Plasmodium falciparum Growth in Different Culture Media," *Front Cell Infect Microbiol*, vol. 12, no. May, pp. 1–14, 2022, doi: 10.3389/fcimb.2022.878496.

[51] O. M. Adeniyi, U. Azimov, and A. Burluka, "Algae biofuel: Current status and future applications," *Renewable and Sustainable Energy Reviews*, vol. 90, no. 2018, pp. 316–335, 2018.

[52] S. Mahanal, S. Zubaidah, D. Setiawan, H. Maghfiroh, and F. G. Muhaimin, "Empowering College Students' Problem-Solving Skills through RICOSRE," *Educ Sci (Basel)*, vol. 12, no. 196, pp. 1–17, 2022.

[53] R. Hidayat, D. Handayani, and R. Darussyamsu, "Validitas Media Pembelajaran E-learning Berbasis Edmodo Pada Materi Kingdom Protista Kelas X SMA / MA The Validity Of Learning Media E-learning Based On Edmodo On Kingdom Protist Material Class X SMA / MA," *Atrium Pendidikan Biologi*, vol. 1, no. 3, pp. 106–114, 2017.

[54] H. Hardianto, S. Mahanal, and S. Zubaidah, "The RICOSRE-FC potential in improving high school students' critical thinking skills," *JPBIO (Jurnal Pendidikan Biologi)*, vol. 8, no. 1, pp. 1–11, Apr. 2023, doi: 10.31932/jpbio.v8i1.2004.