BIO-INOVED
Jurnal Biologi-Inovasi Pendidikan
Volume 7, Issue 2, June 2025 page. 280-288

P-ISSN : 2684-9062 | E-ISSN : 2714-9803
https://ppjp.ulm.ac.id/journal/index.php/bino
DOI: 10.20527/bino.v7i2.22246

Contextual learning using Balinese salak (*Salacca zalacca*) probiotic drink to enhance science literacy in microbiology

Nadya Treesna Wulansari [(1)] *, I Putu Gede Sutrisna [(2)], Ni Wayan Kesari Dharmapatni [(3)]

[(1)] Study Program of Food Technology, Faculty of Technology, Institut Teknologi dan Kesehatan Bali, Denpasar, Bali, Indonesia
[(2)] Diploma IV Program of Nursing Anesthesiology, Faculty of Health, Institut Teknologi dan Kesehatan Bali, Denpasar, Bali, Indonesia
[(3)] Study Program of Nursing, Faculty of Health, Institut Teknologi dan Kesehatan Bali, Denpasar, Bali, Indonesia

** Corresponding Author Email: nadyatreesna@gmail.com*

Article Information

Keyword:
Balinese salak; Contextual learning; Microbiology; Probiotic drinks; Science literacy

Kata Kunci:
Salak bali; Pembelajaran kontekstual; Mikrobiologi; Minuman probiotik; Literasi sains

History:
Received : 10/04/2025
Revised : 15/06/2025
Accepted : 17/06/2025
Published : 20/06/2025

Abstract

The implementation of microbiology learning in higher education is still dominated by conventional, lecture-based methods that emphasize rote memorization rather than critical thinking and problem-solving. This limits students' ability to develop scientific literacy, particularly in applying microbiological concepts to analyze real-world environmental and health-related issues. Studies that specifically explore the utilization of probiotic products made from local plants as learning media in an effort to improve science literacy, especially in the field of biology, are still relatively limited. This study aims to investigate the effect of implementing contextual based learning through the utilization of probiotic drinks made from Balinese salak fruit (*Salacca zalacca*) on improving students science literacy in microbiology topics. This research is a pre-experimental study with One Group Pretest-Posttest design with a total sample of 60 people. Data analysis in this study was Paired Sample T-Test. The results of the analysis showed a significant increase in the average value of the pretest (65.91) and posttest (80.75). Contextual approach through the integration of Balinese salak fruit probiotic drink in microbiology learning proved effective in improving students' science literacy significantly ($p < 0.001$). This approach contributes significantly to the improvement of student's literacy, connection with the local context, and the ability to apply scientific concepts in everyday life.

Abstrak. *Pembelajaran mikrobiologi di pendidikan tinggi masih didominasi oleh metode konvensional berbasis ceramah yang menekankan hafalan dibandingkan pemikiran kritis dan pemecahan masalah. Hal ini membatasi kemampuan mahasiswa dalam mengembangkan literasi sains, terutama dalam mengaplikasikan konsep mikrobiologi untuk menganalisis permasalahan nyata di bidang lingkungan dan kesehatan. Kajian yang secara spesifik mengeksplorasi pemanfaatan produk probiotik berbahan dasar tanaman lokal sebagai media pembelajaran dalam upaya meningkatkan literasi sains, khususnya dalam bidang biologi, masih relatif terbatas. Penelitian ini bertujuan untuk mengetahui pengaruh penerapan pembelajaran berbasis pendekatan kontekstual dengan memanfaatkan minuman probiotik dari buah salak Bali (Salacca zalacca) terhadap peningkatan literasi sains mahasiswa pada topik mikrobiologi. Penelitian ini merupakan studi pre-eksperimen dengan desain One Group Pretest-Posttest dengan jumlah sampel sebanyak 60 orang. Analisa data dalam penelitian ini adalah Paired Sample T-Test. Hasil analisis menunjukkan adanya peningkatan signifikan pada nilai rata-rata pretest (65,91) dan posttest (80,75). Pendekatan kontekstual melalui integrasi minuman probiotik buah salak Bali dalam pembelajaran mikrobiologi terbukti efektif dalam meningkatkan literasi sains mahasiswa secara signifikan ($p < 0,001$). Pendekatan ini memberikan kontribusi nyata dalam peningkatan literasi mahasiswa, keterkaitan dengan konteks lokal, serta kemampuan mengaplikasikan konsep ilmiah dalam kehidupan sehari-hari.*

© 2025 BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan

A. Introduction

Biology education plays a vital role not only in shaping students' conceptual understanding but also in fostering scientific literacy. Scientific learning, which emphasizes the processes of observation, data collection, analysis, and drawing conclusions, is highly relevant for enhancing students' scientific literacy and critical thinking skills (Sutiani, 2021). The development of scientific literacy is increasingly urgent in today's complex world, where individuals are required to evaluate scientific information and make responsible decisions related to health, the environment, and technology (Christensen et al., 2016; Oktaviana et al., 2023; Nefianthi & Wahab, 2024). To meet these challenges, biology education must emphasize inquiry-based learning, evidence-based reasoning, and the integration of real-world contexts into the curriculum.

Strengthening scientific literacy ensures that students not only possess scientific knowledge but are also capable of thinking analytically and acting responsibly in science-related situations (Vieira & Tenreiro-Vieira, 2016; Osborne, 2023). Microbiology, as a branch of biological science, focuses on the study of microorganisms. A central topic in microbiology education is the control of microorganisms, which is directly connected to pressing global issues such as health, food security, and environmental sustainability. Understanding the role of microorganisms in these areas further highlights the importance of integrating microbiological knowledge into efforts to develop students' scientific literacy.

Fidiastuti et al. (2024) and Fujianti et al. (2024) emphasize that microbiology literacy comprises three core competencies: foundational microbiological knowledge, the ability to identify and solve real-world problems, and attitudes and values that reflect an understanding of microbiology's role in supporting life. The implementation of learning microbiology teaching materials in the field is still dominated by using conventional approaches that focus on mastering theoretical material and prioritizing memorization and limited linking of material to the real context of the student environment. This condition has implications for the low level of biological literacy of students. Conventional learning influences scientific literacy by limiting active engagement, critical thinking, and the ability to connect scientific concepts to real-world contexts. Inquiry-based models, as highlighted in the research, offer a more effective approach to fostering scientific literacy. In conventional learning, students often passively receive information, which can result in disengagement and low motivation to explore scientific topics further. Scientific literacy is closely tied to a student's ability to engage actively with the material. Sapriati et al. (2024) found that students who participated in active, inquiry-based learning showed a significant increase in their scientific literacy skills compared to students who were taught using traditional, lecture-based methods.

This is shown by the low average score of microbiology teaching material for students, which is below the minimum competency standard. The microbiology study material that is still relatively low is the inhibitory activity against pathogenic microorganisms. This is reflected in the quiz scores on students' understanding of the inhibitory activity against pathogenic microorganisms. The average quiz score on this teaching material was only 68 out of 100. This indicates the need for more effective teaching strategies and more relevant contextual learning materials. An innovative approach that can be applied to overcome the above problems is the integration of local wisdom-based learning or contextual approaches. The use of contextual learning may enhance students' attitudes by promoting a more positive approach to science education (Suryawati & Osman, 2017).

Integration of local wisdom-based learning can be done through the utilization of functional products such as local plant probiotic drinks that have antibacterial activity. Bali, as an area with rich biodiversity and culture, has great potential in this regard, for example, through the development of probiotic drinks based on Balinese salak. This product not only has health benefits but also contains bioactive compounds that are proven to have antibacterial activity against certain pathogenic microorganisms (Agung & Wulansari, 2023; Wulansari et al., 2022).

Local wisdom-based research can improve students' science learning literacy. This is shown by research by Abdullah (2023), which states that the implementation of wisdom-based learning can improve science literacy in Oeba 3 elementary school students in Kupang City. Similar to the research of Subrata and Rai (2023), ethnopedagogy-based learning about Balinese wisdom can improve science literacy skills and increase students' character about the environment.

The integration of the utilization of local plant-based probiotic drinks in microbiology learning provides an opportunity for students to engage in an inquiry-based learning process. The potential of local plants can be used as a source of biology learning for students (Mumpuni et al., 2013). Through this approach, students not only gain an understanding of fundamental concepts in microbiology but are also encouraged to actively explore and experiment with the potential of local plants as microorganism control agents. The contextual learning approach can increase learning motivation, develop science process skills, and strengthen students' overall science literacy.

Based on the results of the literature review, several studies have explored microbiology learning in educational contexts, highlighting the need for

more relevant, real-world applications to improve scientific literacy. Timmis (2023) emphasizes that current microbiology education requires a paradigm shift to make microbiological knowledge more accessible and meaningful to students. However, no research has been found that specifically integrates the use of local probiotic resources, such as Balinese salak fruit, as a contextual learning medium in microbiology education. This highlights a gap that this study seeks to address.

This shows the importance of contextual learning strategies to improve student science. In this study, the science literacy that will be specialized is biology subject. The use of probiotic drinks made from local ingredients such as Balinese salak in learning biology can be an applicable and relevant approach. In addition to introducing conventional biotechnology concepts such as fermentation, this approach also integrates local contexts close to students' experiences, thus potentially improving conceptual understanding and scientific attitudes towards microbiology and biotechnology. Research that specifically examines the utilization of probiotic drinks from local plants as a learning medium to improve science literacy, especially for biology students, is still very limited. Therefore, this research is important to do as an innovation in microbiology learning that integrates the use of probiotic drinks. This learning innovation is expected to be a solution in improving microbiology learning outcomes, strengthening student science literacy, and fostering concern for the potential and preservation of local resources. This study aims to determine the effect of contextual approach learning based on probiotic drinks of Balinese Salak Bali fruit (*Salacca zalacca*) in improving students' science literacy in microbiology teaching materials.

B. Material and method

This study employed a pre-experimental approach using One-Group Pretest-Posttest Design. The study used questionnaire of science literacy for pretest and posttest. The population consisted of second-semester nursing students enrolled in the 2024/2025 academic year with total 120 students. A simple random sampling technique was applied to select participants based on inclusion criteria. As a result, 60 students were selected as the research sample. The stages of this research are as follows.

Preparation stage

The preparation stage was conducted prior to the implementation of the research. The pattern of integrating Balinese local plant-based learning, namely Balinese salak as a probiotic drink product in microbiology teaching subjects at the preparation stage, is carried out through the following stages:

a) Carry out the identification of microbiology and parasitology learning study materials on certain materials related to the results of the analysis of Balinese salak as an antibacterial probiotic drink, so that several concepts in relevant subjects are selected, namely inhibitory activity against pathogenic microorganisms.
b) Integrate the results of related research in the Semester Learning Plan on related study materials.

Implementation stages

a) Measuring students' initial science literacy by giving pretests to students. Students' initial science literacy was measured using a science literacy test instrument consisting of 5 description questions. This instrument was developed based on science literacy indicators of (1) explaining phenomena scientifically, (2) evaluating and designing scientific investigations, and (3) interpreting scientific data and evidence.
b) The learning activity was conducted by highlighting the potential of a local Balinese plant, Balinese salak (*Salacca zalacca*), as the main ingredient in the development of an antibacterial probiotic beverage, which was integrated into microbiology course content. The intervention was carried out in a single microbiology session using a contextual learning approach. The learning steps began with the delivery of core material related to microbiology and the basic concepts of probiotics. Students were then provided with scientific articles discussing the potential of Balinese salak as an antibacterial probiotic drink. They analyzed the articles using an inquiry-based approach, involving the identification of research variables, examination of experimental data, and drawing conclusions from real case studies. Following the analysis, the learning emphasized the importance of utilizing local plants as sources of innovation for probiotic products. A discussion session was then conducted, in which students presented the results of their analysis of the reviewed articles. The use of local resources aimed to build contextual relevance, enhance students' active engagement, and strengthen their ability to apply microbiological concepts in everyday life, thereby fostering deeper scientific literacy.
c) Measuring students' final science literacy (posttest) after the learning implementation stage. After the intervention, the same science literacy test instrument was given again as a posttest to measure the improvement of students' science literacy.
d) The instrument used to measure the content aspect was first tested for validity to determine whether the questions could be understood properly or not and reliability. The instrument is given to students who have received the subject matter to determine the validity of the items and

the reliability of the test. The instrument validity test was conducted using the Pearson Product Moment correlation technique, which showed that each item was valid with a significant correlation value ($p < 0.05$). The reliability test in this study was carried out using the Cronbach's alpha coefficient to determine the internal consistency of the instrument consisting of 5 items. Based on the results of the analysis, the Cronbach's alpha value was 0.882, indicating the instrument is reliable (Taber, 2018).

Data analysis stage

Data from the measurement of student science literacy in the content aspect is processed and then described to determine the increase in science literacy that occurs. Data analysis used is the paired sample t-Test if the pretest and posttest data are normally distributed (Pallant, 2011).

C. Results and discussion

Preparation for lectures is carried out by referring to the learning objectives and competency achievements outlined in the Semester Learning Plan. Contextual learning in microbiology is delivered through presentation slides, and articles related to Salak Bali probiotic beverages. A pretest is administered before each session, while a posttest is conducted after the completion of the lesson.

Respondent characteristics

The respondent characteristics based on gender were dominated by female students (see Figure 1). There were 13 male students and 47 female students. The number of respondents who are dominated by females has the potential to affect learning literacy outcomes.

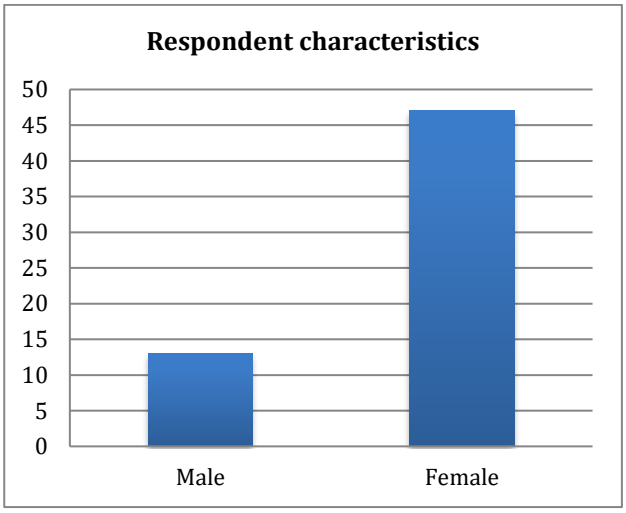

Figure 1
Frequency distribution of respondent characteristics based on gender

The predominance of female respondents has the potential to influence learning literacy outcomes. This is supported by the study conducted by Murphy and Ivinson (2005) in their article gender, assessment, and students' literacy learning: implications for formative assessment, which indicates that females tend to perform better in literacy-related activities, primarily due to their more reflective learning style, greater responsiveness to feedback, and active participation in formative learning processes.

Normality test

The normality test of the pretest and posttest data showed that the data was normally distributed. Testing was carried out using the Kolmogorov-Smirnov test with a total of 60 respondents.

Table 1 Pretest and posttest normality test

	Kolmogorov-Smirnov		
	Statistic	**df**	**Sig.**
Pretest	.090	60	.200
Posttest	.083	60	.200

Based on Table 1, the Kolmogorov-Smirnov test results, a significance value of 0.200 was obtained for the pretest and posttest data. All significance values are above the significance level of 0.05, which indicates that the distribution of pretest and posttest data is normally distributed.

Contextual learning in improving science literacy in college students

The contextual approach used in this learning is based on local Balinese plants, namely Balinese salak which is used as a probiotic drink as teaching media. The results of the pretest and posttest of student science literacy are as Table 2.

Table 2 Student pretest and posttest results

	Minimum	**Maximum**	**Mean**	**SD**	**Sig**
Pretest	58.00	78.00	65.91	4.54	.000
Posttest	70.00	90.00	80.75	4.92	

Based on Table 2, there is an increase in scores between the pretest and posttest results of students. The average pretest score of 65.91 increased to 80.75 on the posttest, with a mean difference of 14.84 points. In addition, the minimum score increased from 58.00 to 70.00, and the maximum score from 78.00 to 90.00. The results of the paired sample t-test on students' pretest and posttest scores showed that $p < 0.001$, indicating that the contextual learning provided, namely, the introduction of the concept of a Balinese salak (*Salacca zalacca*) fruit probiotic drink as an antibacterial agent, is effective in improving students' science literacy. This improvement includes an understanding of basic biological concepts such as

the mechanism of action of probiotics, characteristics of gram-positive and gram-negative bacteria, and the application of probiotics in functional food innovation. This was reinforced by the improvement in the quality of students' essay answers on the posttest, which showed better scientific reasoning, the use of appropriate biological terms, and the ability to integrate theory and research data more comprehensively. Learning by providing materials and articles based on the utilization of local plants is not only theoretical but can also have an applicative and relevant impact on real conditions.

Figure 2
Production of Balinese salak probiotic drink: (A) Balinese salak, (B) Peeled salak fruit, (C) Salak fruit cutting, (D) Fermentation of salak fruit juice, (E) Removal of SCOBY (Symbiotic Culture of Bacteria and Yeast) and filtration the fermentation salak fruit juice, and (F) Balinese salak probiotic drink

The Balinese salak probiotic drink is produced through fermentation. Observing the process of making this probiotic drink can help students connect theory with reality, enhance their understanding of scientific concepts, and develop science process skill. The procedure for making the Balinese salak probiotic drink is shown in Figure 2.

The development of local plant-based learning needs to be optimized because it can support the application of a contextual approach in the educational process and contribute to efforts to preserve national cultural heritage (Fauzi et al., 2024). Local Balinese plants that can be utilized as probiotic beverage products are currently being developed. Innovation in the development of the latest generation of bifunctional juice formulations with improved characteristics, high antioxidant activity, effectiveness as antimicrobial agents, as well as the ability to inhibit pathogen growth, is a potential approach in supporting the distribution of beneficial bacteria while suppressing the presence of pathogenic microorganisms (Tenea & Perugachi, 2025).

In context-based learning, students showed enthusiasm and active participation, especially when expressing opinions in discussion sessions. Students are able to express their views by integrating and summarizing the learning materials that have been obtained with the contents of scientific articles related to probiotic drinks made from Balinese salak fruit. This learning also encourages students' motivation to explore new knowledge relevant to the learning topic. This is reflected in the high intensity of students asking questions and giving responses, both in the interaction between lecturers and students and between students during the discussion. This is consistent with research by Pratama et al. (2019), which states that contextual learning models can improve student learning outcomes.

Contextualized learning based on the potential of local plants is implemented by integrating the principles of constructivism, where learners build their knowledge actively through direct experience and interaction with the environment. In this learning process, learners do not only act as passive recipients of information but as active subjects who construct new understanding based on their prior knowledge. One form of application is through the exploration of relevant research articles, such as the study of salak fruit-based probiotic drinks as antibacterial agents. For example, a study by Wulansari et al. (2022) found that fermented salak Bali extract effectively inhibited *Escherichia coli* growth, with a clear zone of inhibition observed at day 15 of fermentation. By reading, analyzing, and discussing these research results,

students not only obtain actual scientific information but are also trained to think critically, relate theory to real practice, and develop science literacy in a more contextual and meaningful way.

In line with the research of Hasanah et al. (2021), who stated that their research includes seven main components: modeling, questioning, inquiry, learning community, constructivism, authentic assessment, and reflection. Through these activities, students not only obtain actual scientific information but are also trained to think critically, connect theory with real practice, and develop science literacy in a contextual and meaningful way. Students' critical thinking skills improve, especially in the analysis aspect, which often appears in activities such as modeling, question and answer, inquiry, group discussion, and authentic assessment.

One such approach is to integrate local wisdom-based learning media, such as probiotic drinks from Balinese salak fruit (*Salacca zalacca*), which are proven to have antibacterial activity against pathogenic microorganisms. Research from results Wulansari et al. (2022) showed that Balinese salak probiotic drink effectively inhibited the growth of *Escherichia coli*., whereas research from Agung and Wulansari (2023) showed antibacterial activity against *Staphylococcus aureus*. This finding reinforces that fermented products from local plants can be used as contextual learning media to understand microbiology concepts, such as the mechanism of action of probiotics and interactions between microorganisms. The use of local products as learning resources not only enriches learners' biological understanding but also encourages learners to connect scientific knowledge with the potential of local resources in the surrounding environment.

The results of this study are supported by research by Nofiana and Julianto (2018). This study examines the implementation of a learning model that integrates local excellence into biology materials and evaluates the improvement of students' science literacy after the implementation of this learning. The findings showed a significant improvement in students' science literacy skills, which included aspects of content, context, and scientific process. The learning approach that implements regional culture or local wisdom as an object in science learning is known as ethnoscience (Suprapto et al., 2021).

Scientific literacy encompasses a range of definitions, from an individual's capacity to comprehend scientific facts and concepts and analyze scientific data to a society's ability to collectively engage with scientific knowledge and practices. Mastery of science literacy skills is crucial for everyone to have in dealing with science-related problems in life (Kelp et al., 2023). Increasing science literacy, especially in the field of microbiology biology, requires a learning approach that is not only theoretical but also applicable and contextual. Increasing science literacy, especially in the field of microbiology biology, requires a learning approach that is not only theoretical but also applicable and contextual.

Previous studies have stated that the development of scientific knowledge for prospective teachers is important, particularly in the field of microbiology in biology education (Fidiastuti et al., 2024). This literacy not only includes conceptual understanding but also the ability to apply microbiological knowledge in real-world contexts. The use of probiotic beverages made from Balinese salak fruit as a learning medium is a relevant approach. This topic introduces the concepts of fermentation and microorganisms in a contextual manner while also utilizing local potential as an authentic source of learning. In addition, it highlights the significance of using an interdisciplinary approach to foster microbiology literacy through food fermentation, integrating both scientific elements and cultural perspectives (Hauptmann et al., 2025).

Learning that integrates local wisdom has been proven to contribute positively to the development of students' competencies. Several research findings indicate that this approach is effective in significantly improving students' conceptual understanding (Izzah, 2022). This learning strategy aligns with the study by Hidayat et al. (2024), which revealed that the use of biodiversity-related questions based on local potential can significantly enhance students' biology literacy skills. The study showed that integrating local contexts into learning can strengthen students' conceptual understanding and develop their ability to interpret biological information analytically and critically. The implementation of probiotic beverage-based learning using Balinese salak not only provides meaningful and contextual learning experiences but also serves as an effective medium for developing students' science literacy. This development is particularly evident in three dimensions: content knowledge (understanding biological concepts related to probiotics and antibacterial agents), context (applying knowledge to local health and food issues), and scientific processes (interpreting data, formulating hypotheses, and evaluating evidence). These dimensions were measured using specific indicators to track which aspects of science literacy showed improvement.

The integration of learning using instructional media based on local wisdom is in line with the findings of Ula et al. (2025), which showed that science learning modules based on problem-based learning (PBL) containing ethnoscience elements have a high level of validity and are effective in enhancing students' critical thinking skills. Modules incorporating local wisdom enable learners to construct knowledge through contextual experiences and to understand scientific processes in a more applicable and meaningful way. Microbiology learning

through a contextual approach using Balinese salak probiotic media can contribute to the improvement of students' science literacy content, particularly in the aspects of content, context, and scientific processes.

In addition, a study by Najmah et al. (2024) showed a positive correlation between biology literacy and metacognitive ability with students' critical thinking skills. This indicates that enhancing science literacy through a contextual approach, such as the use of Balinese salak probiotic beverages, not only improves conceptual understanding but also fosters reflective awareness and higher-order thinking strategies, which play a crucial role in developing students' critical thinking abilities.

The implementation of contextual learning based on local plants through the use of probiotic beverages made from Balinese salak contributes positively to the enhancement of students' scientific literacy. This learning medium not only connects microbiology concepts with real-life phenomena but also stimulates students' interest and understanding of the vital role of microorganisms in everyday life. This is in line with the findings of Ambarwati and Wilujeng (2023), which show that the development of biodiversity electronic worksheets (e-worksheets) based on local wisdom and culture can significantly enhance students' learning motivation. This increase in motivation becomes a key factor in encouraging active student engagement in the learning process, ultimately contributing to a more optimal achievement of science literacy. The integration of local resources, such as Balinese salak, into the learning process not only reflects cultural values but also strengthens students' scientific understanding in a contextual and meaningful way.

For nursing students, adequate scientific literacy, particularly in the field of microbiology, is a crucial competency that supports evidence-based nursing practice. Through the integration of local wisdom in learning, students are able to connect scientific concepts with traditional health practices and the development of functional products within the community. This aligns with the goals of higher education to produce graduates who are not only academically competent but also capable of critical and contextual thinking. The contextual approach using Balinese salak fruit probiotic drinks contributes significantly to enhancing students' literacy, especially in terms of content understanding, connection to local context, and the application of scientific concepts in real-life situations.

D. Conclusion

For nursing students, adequate scientific literacy, particularly in the field of microbiology, is a crucial competency that supports evidence-based nursing practice. Through the integration of local wisdom in learning, students are able to connect scientific concepts with traditional health practices and the development of functional products within the community. This aligns with the goals of higher education to produce graduates who are not only academically competent but also capable of critical and contextual thinking. The contextual approach using Balinese salak fruit probiotics contributes significantly to enhancing nursing students' literacy, especially in terms of content understanding, connection to local context, and the application of scientific concepts in real-life situations. However, this study has several limitations, one of which is the absence of a control group for comparison. Therefore, future research is recommended to employ an experimental design involving a control group, so that the effectiveness of the learning approach can be more objectively compared with other instructional models.

E. Acknowledgement

The authors sincerely thank all students who participated as respondents in this study. Their engaged contribution and helpful suggestions during the educational activities using local Balinese plant resources were essential in exploring the potential of Balinese Salak probiotic drinks as contextual materials in microbiology education.

F. References

Abdullah, N. (2023). Pembelajaran berbasis kearifan lokal tanaman faloak (*Sterculia quadrifida* R. Br) terhadap literasi sains siswa kelas IV Sekolah Dasar Oeba 3 Kota Kupang. *Jurnal Pendidikan Dasar Flobamorata*, *4*(1), 489-494. DOI: https://doi.org/10.51494/jpdf.v4i1.911

Agung, I. M. P. A., & Wulansari, N. T. (2023). Probiotic antibacterial activity test of Bali salak fruit (*Salacca zalacca* var Amboinensis) against Staphylococcus aureus. *Jurnal Biologi Tropis*, *23*(4), 6-11. DOI: http://dx.doi.org/10.29303/jbt.v23i4.4503

Ambarwati, R., & Wilujeng, P. (2023). Development of electronic worksheet of biodiversity based on local wisdom and culture to enhance student's learning motivation. *Biosfer: Jurnal Pendidikan Biologi*, *16*(1), 82-99. DOI: https://doi.org/10.21009/biosferjpb.27894

Christensen, J. H., Bønnelycke, J., Mygind, L., & Bentsen, P. (2016). Museums and science centres for health: from scientific literacy to health promotion. *Museum Management and Curatorship*, *31*(1), 17-47. DOI: https://doi.org/10.1080/09647775.2015.1110710

Fauzi, A., Siswati, B. H., & Ramadani, S. D. (2024). Low level of local wisdom-based biology education research: What should we do?. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *10*(3), 1098-1106. DOI: https://doi.org/10.22219/jpbi.v10i3.36108

Fidiastuti, H. R., Lestari, S. R., Suhadi, & Prabaningtyas, S. (2024). Developing microbiology literacy in biology education college: future teacher candidates. *Journal of Microbiology and Biology Education*, *25*(2), e00035-00024. DOI: https:// doi.org/10.1128/jmbe.00035-24

Fujianti, A., Ajizah, A., & Noorhidayati, N. (2024). Validity of e-handout diversity bacterial colonies in rhizosphere Citrus nobilis at Karang Bunga Agrotourism Barito Kuala. *Practice of The Science of Teaching Journal: Jurnal Praktisi Pendidikan, 3*(1), 22-28. DOI: https://doi.org/10.58362/ hafecspost.v3i1.58

Hasanah, S. N., Sunarno, W., & Prayitno, B. A. (2021). Improving students' critical thinking skills trough contextual teaching and learning science module. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(2), 98-105. DOI: https://dx.doi.org/10.26737/jipf.v6i2.1895

Hauptmann, A. L., Maroney, S., Bissett Perea, J., & Marco, M. L. (2025). Growing microbiology literacy through interdisciplinary approaches to food fermentations and an Indigenous peoples' rights framework. *Journal of Microbiology and Biology Education*, e00152-24. DOI: https://doi.org/ 10.1128/jmbe.00152-24

Hidayat, A. E., Wisanti, W., & Isnawati, I. (2024). Biological literacy skills of senior high school student using local potential-based biodiversity question sets. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *10*(3), 724-734. DOI: https://doi.org/ 10.22219/jpbi.v8i3.22992

Izzah, N., Suad, S., Kaliaskarova, A., & Santoso, S. (2022). Development of blended learning model based on Jepara's local wisdom to increase student's concept understanding. *Вестник университета Ясави*, *2*(124), 119-130. DOI: https://doi.org/10.47526/2022-2/2664-0686.10

Kelp, N. C., McCartney, M., Sarvary, M. A., Shaffer, J. F., & Wolyniak, M. J. (2023). Developing science literacy in students and society: Theory, research, and practice. *Journal of microbiology & biology education*, *24*(2), e00058-23. DOI: https://doi.org /10.1128/jmbe.00058-23

Mumpuni, K. E., Susilo, H., & Rohman, F. (2013). Potensi tumbuhan lokal sebagai sumber belajar biologi. In *Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning* (Vol. 11, No. 1, pp. 825-829). Retrieved from https://jurnal.uns.ac.id/prosbi/article/view/ 7922

Murphy, P., & Ivinson, G. (2005). Gender, assessment and students' literacy learning: Implications for formative assessment. *Teacher Development*, *9*(2), 185-200. DOI: https://doi.org/10.1080/13664530 500200247

Najmah, N., Rusdi, R., & Ristanto, R. H. (2024). Correlational between: Biological literacy and metacognitive abilities with critical thinking in junior high school students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *10*(3), 1161-1170. DOI: http://dx.doi.org/10.22219/jpbi.v10i3.35137

Nefianthi, R., & Wahab, M. N. N. D. (2024). The analysis of last year junior high school students' scientific literacy in biology topics. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *6*(3), 397-403. DOI:https://dx.doi.org/10.20527/bino.v6i3.20312

Nofiana, M., & Julianto, T. (2018). Upaya peningkatan literasi sains siswa melalui pembelajaran berbasis keunggulan lokal. *Biosfer: Jurnal Tadris Biologi*, *9*(1), 24-35. DOI: https://doi.org/10.24042/biosf. v9i1.2876

Oktaviana, R., Nuraeni, E., & Amprasto, A. (2023). The effectiveness of inquiry lesson-based digestive system materials for training students' science literacy ability. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *5*(2), 187-194. DOI: https://dx.doi.org /10.20527/bino.v5i2.15911

Osborne, J. (2023). Science, scientific literacy, and science education. In *Handbook of research on science education* (pp. 785-816). Routledge.

Pallant, J. (2011). *SPSS survival manual: A step by step guide to data analysis using the SPSS program* (4th ed.). Berkshire: Allen & Unwin.

Pratama, F. A., Faqih, A., & Nurhadiansyah, N. (2019). Contextual learning models to improve student learning outcomes about natural resources. *Action Research Journal Indonesia, 1*(2), 111-122. Retrieved from http://arji.insaniapublishing.com/ index.php/arji/article/view/11

Sapriati, A., Rahayu, U., Sausan, I., Sekarwinahyu, M., & Anam, R. a. S. (2024). The impact of inquiry-based learning on students' critical thinking in biology education programs within open and distance learning systems. *Jurnal Pendidikan IPA Indonesia*, *13*(3), 367-376. DOI: https://doi.org/10.15294/ 7sty9026

Subrata, I. M., & Rai, I. G. A. (2023). Pembelajaran biologi berbasis etnopedagogi dalam peningkatan literasi sains dan karakter peserta didik. In *Prosiding Seminar Nasional Penelitian dan Pengabdian kepada Masyarakat* (Vol. 1, No. 1). Retrieved from https://ojs.mahadewa.ac.id/ index.php/santimas/article/view/3242

Suprapto, N., Prahani, B., & Cheng, T. (2021). Indonesian curriculum reform in policy and local wisdom: Perspectives from science education. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 69-80. DOI: http://dx.doi.org/10.15294/jpii.v10i1.28438

Suryawati, E., & Osman, K. (2017). Contextual learning: Innovative approach towards the development of students' scientific attitude and natural science performance. *Eurasia Journal of mathematics, science and technology education*, *14*(1), 61-76. DOI: https://doi.org/10.12973/ ejmste/79329

Sutiani, A. (2021). Implementation of an inquiry learning model with science literacy to improve student critical thinking skills. *International*

Journal of Instruction, *14*(2), 117-138. DOI: https://doi.org/10.29333/iji.2021.1428a

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in science education*, *48*, 1273-1296. DOI: https://doi.org/10.1007/s11165-016-9602-2

Tenea, G. N., & Perugachi, E. (2025). Innovative functional juice enriched with native probiotics for enhanced nutrition and antimicrobial properties. *Frontiers in Nutrition*, *12*, 1552745. DOI: https://doi.org/10.3389/fnut.2025.1552745

Timmis, K. (2023). A road to microbiology literacy (and more): An opportunity for a paradigm change in teaching. *Journal of Microbiology & Biology Education*, *24*(1), e00019-23. DOI: https://doi.org/10.1128/jmbe.00019-23

Ula, A., Setyono, P., Yamtinah, S., & Havyarimana, C. (2025). Validity of the Content of Science E-Module Based on Problem Based Learning Containing Ethnoscience to Improve Students' Critical Thinking Ability. *Jurnal Pendidikan Sains Indonesia*, *13*(1), 158-177. DOI: https://dx.doi.org/10.24815/%20jpsi.v13i1.41509

Vieira, R. M., & Tenreiro-Vieira, C. (2016). Fostering scientific literacy and critical thinking in elementary science education. *International Journal of science and mathematics education*, *14*(4), 659-680. DOI: https://doi.org/10.1007/s10763-014-9605-2

Wulansari, N. T., Padmiswari, A. I. M., & Damayanti, I. A. M. (2022). The effectiveness probiotic drink of salak bali (*Salacca zalacca*) in inhibiting growth of *Escherichia coli*. *Jurnal Biologi Tropis*, *22*(3), 934-939. DOI: https://doi.org/10.29303/jbt.v22i3.3515