At-Ta'lim: Jurnal Pendidikan
12 (2), 2026, 203-210
Available at: https://ejournal.unzah.ac.id/index.php/attalim

Development of an Augmented Reality-Based Biology E-Module Using a Deep Learning Approach to Improve High School Students' Scientific Literacy

Ni Nyoman Serma Adi*, Dewa Nyoman Oka, Ni Made Serma Wati, I Gusti Lanang Agung Parwata, I Gede Ratnaya, I Dewa Ayu Made Budhyani
IKIP Saraswati, Jalan Pahlawan No.2 Tabanan. 82113, Indonesia
Universitas Pendidikan Ganesha, Jalan Udayana Nomor 11 Singaraja, 81116, Indonesia
e-mail: sermaadi26@gmail.com*
*Corresponding Author

Abstract: This study aims to produce a biology e-module using Augmented Reality technology and a deep learning approach, and meets valid, practical, and effective standards in improving students' scientific literacy skills. The effectiveness test was conducted using a pre-experimental design one-group pretest-posttest design, and the results were analyzed using the N-Gain index. The process of creating the e-module follows a 4-D model consisting of four stages: define, design, development, and disseminate. However, this study only reached the development stage due to time constraints. The study shows that: (1) The development of the e-module obtained an average validity value of 3.4 based on the opinions of experts and practitioners, so it is considered valid; (2) the practicality aspect is met because the implementation of learning runs smoothly and the responses from teachers and students are in the very practical category; and (3) the e-module is proven to be effective in improving scientific literacy skills, as seen from the N-Gain value of 0.56 which is included in the moderate category. Thus, it can be concluded that the biology e-module based on Augmented Reality with a deep learning approach has met the criteria of being valid, practical, and effective, and is suitable for use as a learning medium to improve the scientific literacy of high school students.
Keywords: E-module; Augmented Reality; Deep Learning; Scientific Literacy

How to Cite: Adi, N.N.S., Oka, D.N., Wati, N.M.S., Parwata, I.G.L.A., Ratnaya, I.G., & Budhyani, I.D.A.M. (2026). Development of an Augmented Reality-Based Biology E-Module Using a Deep Learning Approach to Improve High School Students' Scientific Literacy. *At-Ta'lim: Jurnal Pendidikan, 12* (2), 203-210. https://doi.org/10.55210/attalim.v12i2.2497

Introduction

Advances in modern science and technology have driven changes in the way schools teach science, with a focus on improving the standards of the science curriculum in secondary schools. Students must strive to become scientifically literate, meaning they can understand scientific ideas, analyze data, and base their conclusions on facts (Hidayanti & Noviati, 2023). Changes in educational practices are needed to help students better understand complex ideas and develop critical thinking skills, as several studies have revealed that students' current scientific literacy levels are far from adequate (E. Suryani et al., 2024). Based on the 2022 PISA analysis, Indonesian students' science literacy scores are well below the OECD average. Comparative research based on PISA 2022 data shows Indonesia's science score is around 383 points, while the OECD average is around 485 points. Only around 34% of Indonesian students achieve basic competency (Level 2). (OECD, 2023). Biology learning is complex and often abstract, especially material related to cells, tissues, and organ systems. Teaching material using only verbal explanations or static media is generally ineffective in helping students construct comprehensive conceptual representations. This results in poor conceptual understanding and the emergence of misunderstandings. Therefore, learning media that can provide

clearer and more interactive visualizations are needed to facilitate the process of knowledge construction (S. I. Suryani & Sandika, 2022). One option is the implementation of Augmented Reality (AR) technology in the learning process. This technology enables the interactive integration of virtual objects with the real world, thereby enriching the learning experience for students (Sa'diah et al., 2022). The application of AR in education has been shown to enhance conceptual understanding through more vivid three-dimensional visualizations while increasing student participation in learning activities. Furthermore, AR can overcome the shortcomings of traditional media by offering a more relevant and technology-based learning experience (Amalia & Prasetyo, 2025). In addition to increasing motivation and learning engagement, the use of Augmented Reality (AR) also contributes to improving students' scientific literacy because it helps them understand scientific concepts in a more concrete, interactive, and contextual way.

Several studies conducted in Indonesia have shown that augmented reality (AR)-based learning materials significantly improve student academic achievement. Augmented Reality (AR) helps students understand abstract concepts through interactive visualizations, thereby improving their learning outcomes (Adi & Putri, 2025). Furthermore, AR can strengthen students' reasoning and higher-order thinking skills by creating a more engaging and participatory learning environment(Azka & Prasetyo, 2025.). This research suggests that augmented reality may be a breakthrough for students pursuing degrees in biology, which require sophisticated theoretical knowledge. Beyond the use of technology, learning methods are also crucial in improving the quality of education. One important method is deep learning, which emphasizes a deep understanding of concepts, relationships between them, and students' reflective skills. In the deep learning approach, there are three important elements that are often used, namely meaningful learning (meaningful learning), joyful learning (enjoyable learning), and mindful learning (conscious and reflective learning). These three elements support each other to create deep and meaningful learning. (Ramadhan, 2025). When used in conjunction with AR and other technology-based learning strategies, this strategy significantly improves learning outcomes by helping students go beyond memorization; it fosters conceptual understanding (Salsabila & Aryanto, 2026). In line with advances in digital technology, electronic learning materials such as e-modules are also increasingly developing and have the potential to improve the quality of learning. The term "e-module" refers to organized and interactive digital learning resources, allowing students to learn at their pace. Augmented reality (AR) technology, when combined with e-modules, can provide students with a more dynamic, adaptive, and personalized educational experience. Technology-based e-modules have demonstrated their ability to enhance students' independent learning and boost their classroom engagement (Azhari & Nugraha, 2026).

However, the development of Augmented Reality-based e-modules integrated with deep learning approaches is still quite limited, particularly in biology learning at the high school level. A literature review on AR in biology education shows that most studies focus on improving learning motivation, conceptual understanding, visualization of biological objects, and student engagement through constructivist or inquiry-based approaches. However, very little research has been reported explicitly integrating AR with a Deep Learning pedagogical framework (Azzahra et al., 2024). Many studies focus more on the use of AR technology without linking it to a more in-depth learning approach, so the potential of this technology to improve scientific literacy remains underutilized. Furthermore, recent studies have shown that augmented reality (AR) can increase student engagement and enthusiasm for learning, which in turn improves learning outcomes, when used in science classes (Indayana & Indrapangastuti, 2025). The fact that augmented reality (AR) can be integrated into e-modules and other digital pedagogical tools offers great prospects for improving science education and, more broadly, scientific literacy (Isnaeni & Sa'diyah, 2024)

Based on these issues, it is necessary to develop an augmented reality-based biology e-module with a deep learning approach that can help students understand concepts in a more in-depth, interactive, and contextual way. This development is expected to not only contribute to deepening the understanding of biological concepts but also strengthen students' scientific literacy at the high school level. Therefore, the purpose of this study is to create an augmented reality-based biology e-module with a deep learning approach and to test how effective the module is in improving students' scientific literacy. The results of this study are expected to contribute to the development of innovations in technology-based learning and become an alternative solution to improve the quality of teaching.

Method

The research method used in this research is the R&D (Research and Development) method by accommodating the 4D model, namely Define, Design, Develop and Disseminate by Thiagarajan and Semmel. Due to time constraints, the study process was directed to the development stage, thus focusing on the development and testing of the learning e-module. The effectiveness of the e-module was tested using a pre-experimental design with a one-group pretest-posttest. In this approach, one group is tested with a pre-treatment pre-test and a post-treatment post-test to determine whether there has been an improvement in student performance. This study was conducted at SMA Negeri 2 Tabanan in the 2025/2026 academic year, with the participation of 32 10th-grade students. The research subjects consisted of experts, practitioners, and students. Expert validation was conducted by two lecturers who acted as assessors for the material and construct aspects, while practitioner validation involved eight high school biology teachers. The product trial was conducted in one class, 10th-grade Science 3. The sample was selected using the Purposive Sampling technique based on certain considerations, namely students who fit the research characteristics, teachers of related subjects, or schools that have research support facilities. The research focused on an augmented reality-based biology e-module with a deep learning approach learning using the Web-based Application Assembler Edu. Data collection utilized several instruments, including validation sheets, observation sheets from the learning implementation, questionnaires for teacher and student responses, and a scientific literacy test on the material of Biodiversity and Ecosystems. All of these instruments were previously validated by experts and analyzed using Gregory's formula to ensure their feasibility. The indicators measured to determine students' scientific literacy are: Describing phenomena scientifically, evaluating and designing investigations scientifically, interpreting data and evidence scientifically. The collected data were analyzed descriptively and quantitatively to assess product quality based on three aspects: validity, practicality, and effectiveness. Validity was assessed based on expert assessments of content and constructs, with categories ranging from very valid to not valid. Practicality was measured through the implementation of the learning and responses from teachers and students, which were analyzed based on average scores and converted into predetermined criteria.

The effectiveness of the e-module was measured by observing the development of learning outcomes, analyzed through the N-Gain score obtained from comparing pretest and posttest scores. By analyzing the data using the N-Gain test, researchers were able to determine the extent to which students' scientific literacy skills improved after using the developed electronic module. N-Gain analysis is used to measure learning effectiveness based on a comparison of pretest and posttest scores literacy (Zendrato et al., 2024).

Results and Discussion

In the define phase, a needs analysis was conducted, including a review of the curriculum, student characteristics, and the biology learning situation in grade 10 at SMA Negeri 2 Tabanan. The

results of this analysis indicated that teaching methods were still dominated by traditional approaches that were not fully effective in supporting the visualization of abstract concepts. Students faced difficulties in understanding material that required three-dimensional representations, such as cell structure and organ systems. Furthermore, scientific literacy skills were not optimally developed because learning did not fully focus on improving critical thinking skills. These findings indicate a need for innovation in learning that can integrate technology with appropriate pedagogical methods. Therefore, the development of an augmented reality-based e-module with a deep learning approach was considered a relevant solution, as it could meet the visualization needs while simultaneously fostering deeper conceptual understanding.

The design phase resulted in an e-module design that combined three main elements: biological material, augmented reality technology, and a deep learning approach. This e-module was structured to include learning objectives, core material, AR-based exploration activities, exercises, and evaluations. The deep learning approach was implemented through activities that encouraged students to connect concepts to relevant phenomena, conduct independent exploration, and reflect on the learning process. At the same time, biological objects are displayed in interactive three-dimensional forms using augmented reality technology. The goal of this integration is to make learning more engaging and interactive so that students can gain a deeper understanding of the material, rather than simply memorizing facts and figures.

The development phase was the primary focus of the research, encompassing expert validation, practicality testing, and evaluation of the effectiveness of the learning instruments. Assessments conducted by material and construction experts indicated that the e-module was categorized as valid to highly valid. Content validity indicates that the content aligns with the curriculum, is scientifically accurate, and relevant to learning needs. Construct validity, on the other hand, indicates that the presentation elements, language use, and application of technology and learning approaches have been structured systematically and logically. Analysis using Gregory's (2000) formula demonstrated a high level of agreement among the validators, thus deeming the learning tool valid for testing. This high level of validity indicates that the resulting product meets quality standards in both substance and design. The products created in this research include learning tools such as Lesson Implementation Plans (RPP), biology e-modules, and evaluation instruments. Before being used in the field test, all instruments underwent a validation process by two lecturers. Furthermore, the science literacy test was field-tested and demonstrated that all items were suitable for use in research.

Based on the validity test findings shown in Table 1, two phases of assessment were conducted for this learning module: expert validation and empirical validation. As practitioners, biology professors and instructors participated in the empirical validation process. The validation process yielded an average validity score of 3.4. Therefore, the e-module is feasible to implement, although some adjustments may be needed based on the validators' suggestions for further refinement. Some suggestions from the validator are: Correct some scientific terms to be more consistent and in accordance with scientific language rules, Correct the wording of some questions to avoid multiple interpretations, and Work steps in the LKS need to be made clearer and more structured.

Table 1. E-module validation test results

Aspects Tested	Validity Results	Criteria
E-Module Content	3.5	Valid
Lesson Plans	3.5	Valid
Evaluation Tools	3.4	Valid
Worksheets	3.4	Valid
Average	**3.4**	**Valid**

The validity criteria were determined based on the mean scores obtained from expert judgments using a 4-point Likert scale. The product was categorized as highly valid if the mean score ranged from 3.26 to 4.00, valid if it ranged from 2.51 to 3.25, fairly valid if it ranged from 1.76 to 2.50, and not valid if it ranged from 1.00 to 1.75. A product was considered feasible for use when it achieved at least the valid category (mean score ≥ 2.51).

The level of validity of the designed learning e-modules is influenced by several aspects, one of which is the alignment of the e-module's constituent elements with the validation instrument criteria deemed valid by experts. This is reflected in the average validity score achieved, which falls within the valid category. The designed e-modules have passed both content and construct validity testing. The developed material aligns with the stated learning objectives and is based on applicable theoretical ideas, thus ensuring content validity. These results are consistent with research by Suci Ramanda et al. (2023), which found that modules developed using reference theory are more likely to pass validation.

Meanwhile, construct validity is evident in the systematic relationships between components within the learning e-modules. The integration between the sections indicates that the module structure is structured logically and consistently. By meeting these two validity aspects, the resulting e-module can be declared valid and suitable for use in learning activities, both in terms of content and construction.

The practicality of the e-learning module was assessed through three key indicators: learning implementation, teacher reactions, and student reactions. The results of the practicality test, presented in Table 2, demonstrate that the designed e-module has a very good level of practicality. Learning strategies can be implemented according to plan using observation data. Teachers can implement the e-module effectively, while students can participate smoothly in learning activities. Student responses indicate that the use of the AR-based e-module provides a more engaging and digestible learning experience. When presented in a three-dimensional format, ideas previously difficult for students can be easily grasped. Furthermore, there was a significant increase in student engagement in their own education.

Conversely, teacher feedback indicates that the e-module is easy to use and effectively supports learning implementation. This demonstrates that the learning tool is not only practical from the user's (teacher's) perspective but also provides convenience and tangible benefits to students in their learning process.

Table 2. Results of the module practicality test

Aspects Tested	Practicality Test Results	Category
Module implementation	3.4	Practical
Teacher response	3.5	Very practical
Student response	3.5	Very practical
Average	**3.5**	**Very practical**

The study findings show that the AR-based biology e-module with an immersive learning approach is considered practical. The learning implementation level received an average score of 3.4 (practical), while responses from teachers and students each achieved an average score of 3.5 in the very practical category. This achievement is influenced by the module's well-planned structure, accompanied by easy-to-understand instructions, comprehensive materials, and evaluation tools that help assess student abilities. Furthermore, the module's development has been adapted to students' learning needs, considering that traditional teaching materials such as textbooks or worksheets are often irrelevant and difficult to apply in the teaching and learning process. The next step is to evaluate

the e-module's effectiveness through a science literacy test that includes a pretest and posttest, supported by a student response questionnaire. The effectiveness analysis was conducted by calculating the N-Gain, and the results are presented in Table 3.

Table 3. Results of the analysis of the effectiveness of the e-module using the n-gain formula

Components	Average Score		Skor N-Gain	Category
	Pretest	Posttest		
Number of Students	32	32	0,56	Moderate
Lowest Score	3,84	53,84		
Highest Score	34,61	80,74		
Average Score	**17,54**	**64,53**		

Analysis of the effectiveness of the e-module, conducted using the N-Gain calculation, showed an increase in students' scientific literacy outcomes. The average pretest score was recorded at 17.54, then increased to 64.53 in the posttest. Students' scientific literacy skills were shown to improve significantly after the implementation of the e-module. The N-Gain value of 0.56 is considered moderate, indicating that the AR-based biology e-module utilizing deep learning successfully improved students' scientific literacy levels. The moderate N-Gain value is certainly influenced by several factors, such as differences in students' initial abilities and limited learning time. Therefore, a moderate N-Gain value still indicates that the product or learning implemented is effective and can significantly improve students' abilities. The level of achievement of each scientific literacy indicator was also analyzed using the N-Gain value. Table 4 shows the detailed achievement for each metric.

Table 4. Results of achievement of each scientific literacy indicator

Components	Average Score		Skor N-Gain	Category
	Pretest	Posttest		
Describe Phenomena Scientifically	26.56	72.65	0.62	Moderate
Evaluate And Design Research Scientifically	0.78	56.25	0.55	Moderate
Interpret Data And Evidence Scientifically	17.18	62.27	0.54	Moderate

With an N-Gain score of 0.62, scientific explanations of events proved to be a crucial component. The N-Gain score was 0.55 for the section related to evaluation and design of scientific research and 0.54 for the section related to interpretation of data and scientific evidence. Overall, the results for each aspect of scientific literacy after implementing the E-Module can be categorized as good. Differences in N-gain between aspects are influenced by variations in student abilities. While some students have exceptional memory and comprehension skills, others require more time to fully absorb the material (Rahmawati et al., n.d.). Students' overall scientific literacy skills improved when their N-Gain scores were moderate across all categories.

When students were able to connect theoretical ideas with experimental findings from animal and plant cells, they demonstrated progress in the scientific explanation of events. The biology e-module, based on augmented reality and using a deep learning approach, provided visual illustrations and observational videos that helped students identify procedural errors and formulate solutions aligned with scientific concepts. The use of learning materials supplemented with images and animations has been shown to positively contribute to improving scientific literacy (Fatikha, 2026). Furthermore, learning activities that encourage students to understand phenomena and generate hypotheses also contribute to developing their ability to explain phenomena scientifically (Musfirayanti et al., 2024a). Learning that connects material to everyday situations can increase student interest and participation. The presentation of real-life phenomena makes students more

enthusiastic about understanding the scientific concepts being studied (Musfirayanti et al., 2024b). In indicators related to the evaluation and design of scientific research, student skill improvement is in the moderate category. This can be seen from changes in student abilities before and after the implementation of the E-Module. Before the learning process began, students faced challenges in formulating procedures for observing plant cells, but after the learning process, students became more proficient in designing the steps for these observations.

The integration of augmented reality technology with a deep learning approach in the E-module enables students to identify problems, design procedures, collect information, and evaluate results, effectively supporting the development of their scientific literacy. The limitations of this study are: This study was only conducted in one school so that the results of the study cannot be generalized widely, The study only focused on two specific biology materials so that the effectiveness of e-modules on other materials is not yet known, The use of Augmented Reality-based e-modules still depends on the availability of smartphone devices and the quality of students' internet networks and The study only measures students' scientific literacy abilities in certain aspects so that it does not cover all indicators of scientific literacy as a whole.

Conclusion

Based on the results of the study, it can be concluded that: (1) Using an average score of 3.4, the newly designed biology E-module based on augmented reality using deep learning techniques demonstrates good validity. (2) The resulting E-Module meets all the specified requirements practically. The average score of 3.41 in the practical area for the learning implementation over four sessions clearly demonstrates this. As an added bonus, the implementation of the module received an average score of 3.5 from both teachers and students, placing it squarely in the “very practical” category. Using an N-Gain value of 0.56, which falls within the moderate range, the resulting e-module meets the effectiveness criteria, indicating that students’ abilities improved after using the module. The results of this study are expected to be a reference for teachers and researchers in developing innovative technology-based learning media to face the demands of 21st century learning.

Acknowledgment

The author would like to express his gratitude to the Saraswati Institute of Teacher Training and Education for the academic support and facilities provided, which enabled the successful completion of this article. He also thanks the lecturers and colleagues who provided input, scientific discussions, and constructive criticism during the preparation of this article. Furthermore, he appreciates the contributions of researchers and academics whose work served as primary references in the development of the Augmented Reality-Based Biology E-Module with a Deep Learning Approach to Improve High School Students' Scientific Literacy.

References

Adi, C. N. S., & Putri, D. A. P. (2025). Pengembangan Aplikasi Augmented Reality untuk Visualisasi Interaktif Pembelajaran Fisika. *Jurnal Pendidikan dan Teknologi Indonesia*, *5*(3), 775–792. https://doi.org/10.52436/1.jpti.701

Amalia, R., & Prasetyo, T. (2025). *Pengembangan Media Pembelajaran Augmented Reality Sebagai Inovasi Pendidikan Di Era Revolusi Industri 4.0: Kajian Literatur Sistematik*. *5*(2). https://doi.org/10.37081/jipdas.v5i2.2826

Azhari, N. P., & Nugraha, F. A. (2026). *Biofun Ar: Enhancing Primary Student’s Engagement In Science Learning Through Augmented Reality*. *10*(1). https://doi.org/10.26811/didaktika.v10i1.2085

Azka, N., & Prasetyo, Y. (2025.). *Pengembangan Media Augmented Reality Jarkomify Untuk Meningkatkan Logical Thinking Siswa. Situs Jurnal Https://Sintek.Stmikku.Ac.Id/Index.Php/Home*. (2)https://doi.org/10.56995/sintek.v5i2

Azzahra, W., Diana, S., Nuraeni, E., Yusni, D., & Andriyatno, I. (2024). The Eurasia Proceedings of Educational & Social Sciences (EPESS) The Eurasia Proceedings of Educational Integration of Augmented Reality (AR) in Biology Education: A Systematic Literature Review. *& Social Sciences (EPESS)*, *34*. www.isres.org

Fatikha, F. S. (2026). *Pengaruh Model Discovery Learning Berbasis Video Animasi Dalam Meningkatkan Literasi Sains Siswa Sekolah Dasar*. *7*(1).

Gregory, R.J. 2000.Psychological Testing History, Principles And Application. Boston: Allyn And Bucan.

Hidayanti, N., & Noviati, W. (2023). *Pengembangan E-Modul Biologi Berbasis Problem Based Learning Untuk Meningkatkan Literasi Sains Siswa*. *8*(1).

Indayana, S. A., & Indrapangastuti, D. (2025). *Inovasi Penggunaan Media Pembelajaran Berbasis Augmented Reality (AR) Untuk Meningkatkan Hasil Belajar IPAS Siswa Sekolah Dasar*.

Isnaeni, N., & Sa'diyah, C. (2024). *Mengoptimalkan Kemampuan Literasi Sains dengan Earth Exploration: E-Modul Berbasis Augmented Reality Berbantuan Assemblr EDU*.

Musfirayanti, M., Mustakim, M., & Hamna, H. (2024). Efektivitas Penggunaan Media Pembelajaran Gambar Seri terhadap Peningkatan Literasi Peserta Didik. *Jurnal Basicedu*, *8*(4), 2953–2967. https://doi.org/10.31004/basicedu.v8i4.8302

OECD. (2023). PISA 2022 Results (Volume I): The State of Learning and Equity in Education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Rahmawati, S., Anugraheni, D. D., Anindyatama, S., & Istiyati, S. (2025). *Penerapan model problem based learning untuk meningkatkan keterampilan membaca pemahaman pada peserta didik kelas IV sekolah dasar*. *11*. https://doi.org/10.20961/jpiuns.v11i2.109653

Ramadhan, A. (2025). Pengaruh Meaningful, Joyful, dan Mindful Learning Sebagai Pilar Deep Learning terhadap Hasil Belajar: Literature Review. https://doi.org/10.62159/jpt.v6i2.1736

Sa'diah, S., Ruhiat, Y., & Sholih, S. (2022). Pengembangan E-Modul Interaktif Berbasis Augmented Reality Untuk Siswa Sekolah Dasar. *Vox Edukasi: Jurnal Ilmiah Ilmu Pendidikan*, *13*(1), 21–29. https://doi.org/10.31932/ve.v13i1.1489

Salsabila, S. P., & Aryanto, S. (2026). *Media Augmented Reality Berbasis Deep Learning Dalam Materi Kekayaan Suku Bangsaku: Tinjauan Pustaka*. *11*.

Suci Ramanda, E., Yogica, R., Rustiono, R., & Selaras, G. H. (2023). Validitas E-Modul Interaktif Menggunakan Smart Apps Creator Bermuatan Pendekatan Kontekstual tentang Materi Ekosistem untuk Peserta Didik di SMA: (Validity of Interactive E-Modules Using Smart Apps Creator Containing Contextual Teaching and Learning about Ecosystem Materials for High School Students). *BIODIK*, *9*(2), 93–102. https://doi.org/10.22437/biodik.v9i2.20225

Suryani, E., Nurfathurrahmah, N., & Herman, H. (2024). Pengembangan E-Modul Biologi Berbasis Model Pembelajaran Project Based Learning untuk Siswa SMP. *JagoMIPA: Jurnal Pendidikan Matematika dan IPA*, *4*(4), 789–797. https://doi.org/10.53299/jagomipa.v4i4.916

Suryani, S. I., & Sandika, B. (2022). Pengembangan E-Modul Biologi Dilengkapi Tokoh Kartun Materi Sistem Gerak Siswa Kelas Xi Mipa Sma. *Jurnal Inovasi Pembelajaran Biologi*, *3*(1), 21–30. https://doi.org/10.26740/jipb.v3n1.p21-30

Thiagarajan, S; Semmel, D.S; & Semmel M.I. 1974. *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Indiana: Indiana University.

Zendrato, E. K., Gea, H. A., Telaumbanua, G. C., Gea, F. K., Halawa, E. K., Hulu, E. N., Telaumbaua, H., Gulo, F. N., & Harefa, E. (2024). Efektivitas Model Project-Based Learning Terintegrasi STEM Dalam Peningkatan Kemampuan Literasi Sains. Indo-MathEdu Intellectuals Journal, 5(4), 4842–4850. https://doi.org/10.54373/imeij.v5i4.1615