

Exploration of the Need for Developing ARCS Model-Based E-Module in Biology Learning: A Mixed-Methods Study

Naila Zulfa Naadhiroh^{1*}, Sunardi², Fatma Sukmawati³

^{1,2,3} Educational Technology Department, Universitas Sebelas Maret, Indonesia

¹nailazulfanaadhiroh1@student.uns.ac.id, ²sunardi.ipuns@staff.uns.ac.id,

³fatmasukmawati@staff.uns.ac.id

ARTICLE INFO

Article History:

Received : 13-01-2026

Revised : 23-03-2026

Accepted : 30-03-2026

Online : 10-04-2026

Keywords:

ARCS Model;

Biology Learning;

E-Module;

Motivation.



ABSTRACT

This study addresses the limited use of interactive digital teaching materials and the low level of student motivation in Biology learning. This study aims to analyze needs and explore the potential for developing e-modules based on the ARCS (Attention, Relevance, Confidence, Satisfaction) model in Biology learning. The research employs a mixed-methods approach with an exploratory sequential design. The qualitative phase involved interviews with three teachers, while the quantitative phase included 198 students through a distributed questionnaire. The results indicate that Biology learning still faces various challenges. Teachers reported that common teaching obstacles relate to student motivation and stated unfamiliarity with, and lack of implementation of, the ARCS model in their teaching. The majority of students expressed a desire for teaching materials that are more engaging and enjoyable, supplemented with images, animations, or videos. Both students and teachers showed interest in developing e-modules, viewing these as resources that can enhance motivation, facilitate understanding of the material, and support independent learning. These findings suggest that the ARCS-based e-module holds potential as a relevant solution for improving the quality of Biology learning through a motivational approach. This study provides a foundation for the development of the ARCS model-based e-module and recommends opportunities for further research on its effectiveness.



This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license

A. INTRODUCTION

Advances in information and communication technology have expanded educational opportunities, especially in the development of teaching materials. Teaching materials are resources systematically designed according to the curriculum that support content knowledge, skills, and attitudes (Kosasih, 2020; Nisa et al., 2024). One form of technology's influence on education is its use as digital teaching materials. Digital teaching materials are learning resources published in digital format, containing text, images, and other interactive media accessible via computers or other digital devices (Yulaika et al., 2020).

Building on these technological advancements, various types of teaching materials can be used in the learning process, including a module. Using a module encourages students to engage in more active learning. A module is defined as a teaching material, systematically and attractively designed, for students to study independently to achieve the expected competencies (Kosasih, 2020). One innovative way to integrate a module with technology is the Electronic Module (E-Module). An e-module is a digital module containing text, images, graphs, animations, videos, and simulations of electronic materials that can be accessed anytime, anywhere to help students understand the

material, improve learning outcomes, and develop scientific context, processes, content, and attitudes (Lastri, 2023).

Furthermore, an e-module not only conveys information but also fosters a learning environment that supports motivation. E-module can increase students' motivation to learn independently (Cahyanto & Afifulloh, 2020). Motivation drives students to focus and commit to their goals. Therefore, objectives and strategies should engage students in activities that enhance their motivation to gain the required knowledge and skills (Brophy, 2004). Motivation encompasses a person's desires, choices, and commitments, and studies of motivation seek to uncover the fundamental factors that prompt individuals to behave in certain ways (Keller, 2010).

The ARCS Model, an acronym for Attention, Relevance, Confidence, and Satisfaction, was developed by John M. Keller as a motivational framework for analyzing and designing learning experiences that motivate students. Its four components outline conditions needed to keep students engaged and maintain long-term motivation. In addition to motivating learners, ARCS informs the design of learning strategies that sustain student interest in the content and the process. The ARCS Model helps integrate motivational components into learning experiences and materials (Jääskä et al., 2022).

The Merdeka Curriculum requires more creative, flexible, and independent learning. It encourages information technology as primary support for learning (Novibriawan, 2023). However, in practice, Biology learning at the senior high school level still faces several significant challenges. Use of teaching materials, especially digital ones, remains low, and most students have not learned with interactive multimedia. As a result, Biology concepts, which are often abstract and complex, become difficult for students to understand. Learning also tends to be conventional and less engaging. Students also show a high dependency on teachers, indicating that their ability to learn independently has not been optimally developed. These conditions highlight a mismatch between the expectations of the Merdeka Curriculum and the actual learning practices in the classroom, particularly in terms of integrating technology and fostering student motivation.

Several studies support the potential of overcoming these challenges. Research by (Wulandari et al., 2020) finds that using an interactive e-module influences student motivation and learning outcomes. Similar research by (Prihastuti & Sukaesih, 2024) shows that an interactive e-module can attract students' interest in reading and improve scientific literacy. Another study by (W.S. Sembiring et al., 2021) finds that the developed e-module is valid, suitable for learning, and helps students learn independently. However, these studies generally focus on the final e-module product and have not specifically examined the needs for an e-module designed based on the motivational ARCS model. Consequently, there is a need to identify the requirements as a foundation for developing a more relevant and effective e-module.

Therefore, this study offers novelty by focusing on a needs analysis of an ARCS model-based e-module, which serves as a foundational step before product development. By identifying students' and teachers' needs, this research aims to bridge the gap between technological potential, motivational design, and actual classroom conditions.

Based on these conditions, this research explicitly aims to analyze the needs and explore the potential or need for an ARCS model-based e-module in Biology learning at the high school level. Specifically, this study seeks to identify current learning conditions, examine students' and teachers' needs for teaching materials, and explore the potential implementation of ARCS-based e-modules. The findings of this study are expected to provide a foundation for developing relevant digital teaching materials that support students' learning motivation.

B. METHODS

This research employed a mixed-methods approach, combining qualitative and quantitative data collection and analysis within a single, integrated investigative framework (Creswell & Creswell, 2018). Leveraging the strengths of both methods, this approach results in an in-depth and holistic analysis.

Research Design

The study used an exploratory sequential design, in which research begins with a qualitative phase to explore the phenomenon and inform instrument development, followed by quantitative testing of those instruments (Creswell & Creswell, 2018). This design emphasizes building instruments or hypotheses from qualitative findings, then testing them quantitatively.

Population and Sample

The population of this study consisted of senior high school students and biology teachers. The sample included three biology teachers and 198 students from one selected senior high school. The sampling technique used for teachers was total sampling, involving all three Biology teachers as research participants. Meanwhile, the sampling technique used for students was convenience sampling, in which participants were selected based on their availability during data collection. A total of 198 students who were present and willing to complete the questionnaire were included as the sample.

Data Collection

The research instruments consisted of interview guidelines and questionnaires. Qualitative data were collected through semi-structured interviews with three biology teachers. Qualitative data obtained from interviews were analyzed using thematic analysis, which involved data reduction, data display, and conclusion drawing. The analysis focused on identifying patterns related to learning conditions, challenges, and the need for teaching materials. Quantitative data were collected through questionnaires administered to 198 students. Quantitative data from questionnaires were analyzed using descriptive statistics in the form of percentages to describe students' responses. The results were then interpreted and integrated with qualitative findings to provide a comprehensive understanding of the research problem.

C. RESULT AND DISCUSSION

1. Current Learning Conditions

Table 1. Interview results with teachers regarding biology learning conditions

Aspect	Findings
Teaching Methods	Teachers employ various methods, including lectures, discussions, presentations, practical work, Q&A sessions, and assignments.
Learning Models	Teachers utilize several models, such as inquiry-based learning and problem-based learning.
Teaching Materials	Teachers use textbooks, Student Worksheets, PowerPoint slides, videos, and other web resources.
Student Engagement in Learning	Student engagement varies considerably and is sometimes notably low in certain classes or sessions.
Challenges in Learning	Teachers observe insufficient student motivation for learning, evidenced by a lack of interest or enthusiasm to participate in learning activities.

The interview results show that teachers use a variety of teaching methods and models. This variety reflects how teachers adapt to subject content and student needs. However, teacher-centered methods, such as lectures, still dominate and do not foster active participation. As a result, students remain passive and rely on the teacher. (Rozali et al., 2022) found that teacher-centered learning leads to passive learning, low participation, a lack of meaningful learning, and mere knowledge transfer, which reduce student outcomes. The fact that low engagement remains common in Biology education confirms this issue. The cause is not just teaching methods but also a lack of teaching materials for independent activities. This points to the need for more interactive materials that support independent work and make learning more meaningful.

Meanwhile, the teaching materials used in instruction are quite diverse. The use of various media indicates that teachers are familiar with employing digital technology. However, these materials are fragmented and not integrated into a cohesive learning package, leading to inconsistent student experiences. Furthermore, even when using the same digital tools, teachers can implement highly diverse instructional practices based on their teaching strategies (Kadluba et al., 2025). Digital teaching materials must integrate text, visuals, activities, and assessments into a single platform. This highlights the need for an e-module that is interactive, integrated, and addresses motivational elements.

The limitations of conventional media, which lack interactive elements and visualisation, negatively impact the understanding of abstract Biology concepts, as students receive information only one-way without opportunities for exploration. Boring conventional learning can limit student interaction and teacher creativity, thereby reducing comprehension and hindering retention (Narpila et al., 2025). Consequently, the learned concepts remain merely theoretical, making it difficult for students to build a stronger understanding. This condition can also lower learning motivation because the material is perceived as boring and fails to spark the curiosity needed for deeper understanding. This finding reinforces the need for digital teaching materials not only for content delivery but also to provide a learning experience that allows students to interact with content independently.

The main challenge in Biology learning is motivating students. Motivation drives the achievement of learning goals. It is influenced internally by desire, interest, drive, and expectations, and externally by unengaging lessons and poor learning environments (Faristin et al., 2023). Without motivation, learning goals are not met. Teachers must creatively stimulate motivation to boost student interest and involvement (Suharni, 2021). This finding indicates that the teaching materials and strategies currently used are not yet effectively meeting students' motivational needs.

Overall, the current learning conditions show that although a variety of methods, models, and media are used, the primary challenge lies in student motivation and engagement. This highlights an urgent need for innovative teaching materials that not only present content in an integrated manner but also enhance student motivation to learn. It is essential to act on these findings by developing integrated, interactive, and systematically designed teaching materials using the motivational ARCS approach to actively improve learning quality.

Table 2. Student questionnaire results on biology learning

Aspect	Percentage	
	Yes	No
Students find Biology a difficult subject	55.1%	44.9%
Students often have difficulty understanding Biology terms or concepts	63.6%	36.4%
Students often have difficulty following Biology lessons in class	40.9%	59.1%
Students try to find additional learning resources (books, the internet, videos) to understand the Biology material	81.8%	18.2%
Students feel that the teacher's method of delivering Biology material is easy to understand	65.7%	34.3%
Students feel that the current Biology teaching materials are not very engaging	55.6%	44.4%
Students feel that the teaching materials used by the teacher do not adequately support their understanding	55.6%	44.4%
Students feel that the current Biology teaching materials are not very helpful in the learning process	55.1%	44.9%
Students find the Biology teaching materials to be boring	53.5%	46.5%
Students find it easier to understand Biology if teaching materials include images, animations, or videos	91.9%	8.1%

The questionnaire results indicate that a majority of students still face challenges in learning Biology. Specifically, 55.1% find it difficult and 63.6% struggle with its terminology and concepts. This reflects the fact that Biology’s scientific terms and abstract ideas are key obstacles. This aligns with the findings of (Sari & Ferry, 2024), who highlight that students find Biology difficult due to its subject’s complexity and abstract characteristics.

However, only 40.9% reported difficulty following classroom instruction, suggesting that the main challenge lies not in the teacher's delivery of the material during class, but in comprehending the concepts, which require more concrete visualisation and explanation. This indicates that the core issue is not the teacher's instructional method, but rather a lack of visual aids and concrete explanations necessary for students to grasp the concepts. Concepts that may be abstract or difficult to understand verbally can become more accessible through visualisation. This is supported by (Annisa, 2025), who emphasises that scientific visualisation plays a crucial role in enhancing students' conceptual understanding in Biology, particularly when studying abstract material.

Interestingly, students exhibit a relatively high degree of independent learning initiative. A significant 81.8% actively seek additional learning resources, such as books, internet sources, or videos, to aid their understanding. Students’ learning autonomy is influenced by their learning motivation (Amalia et al., 2022). This demonstrates that students possess intrinsic motivation to learn. However, their need for supplementary materials suggests that the classroom resources do not fully meet their comprehension needs. While 65.7% of students find the teacher's method of delivering the material relatively easy to understand, their perception of the teaching materials points in the opposite direction. This situation highlights a gap between the teacher's presentation and the teaching materials, which do not yet fully support students' learning needs.

A majority of students perceive current Biology teaching materials as suboptimal: 55.6% find them unengaging and not supportive of understanding,

55.1% say they are not helpful, and 53.5% find them boring. This underscores a need for innovation. Additionally, 91.9% believe they would understand Biology more easily with images, animations, or videos, supporting the integration of visual and interactive elements to enhance interest and comprehension. Visually appealing, interactive learning content not only boosts students' motivation to participate but also facilitates understanding and retention of the concepts being taught (Pua et al., 2025).

Overall, current Biology instruction faces obstacles related to the complexity of the subject matter and the inadequacy of available teaching materials, which are not yet capable of optimally facilitating student understanding and meeting their learning needs. This situation confirms the urgency of developing teaching materials that can integrate multimodal content, motivational strategies, and interactive presentation to improve both student understanding and the learning experience.

2. The Need for Supplementary Teaching Materials

Table 3. Interview results with teachers regarding the potential of ARCS model-based e-module

Aspect	Findings
Digital Teaching Materials	There have been previous e-laboratory and e-module resources, but the e-module has never been used or provided to students due to accessibility issues. The e-module is in PDF or flipbook format and includes videos.
ARCS Motivation Model	Unfamiliar with the ARCS model and have never used it in teaching.
Interest in ARCS-Based E-Module	Interested in developing engaging, digitally formatted teaching materials to support the learning process. Teachers see e-module as having the potential to stimulate student interest and motivation, and believe that digital formats are generally more aligned with current student learning habits.
Content of ARCS-Based E-Module	Should include visuals such as images and videos, and tests with feedback
Support Facilities and Infrastructure	Students have smartphones, and the school also provides internet access via Wi-Fi. However, there is potential for network issues if the Wi-Fi is used simultaneously by many users.

Interviews with teachers reveal that digital teaching materials have been utilized in the school through e-laboratory and e-module. However, teachers explained that the previously available e-module was never distributed to students due to accessibility and distribution challenges. This situation confirms that effective use of digital teaching materials in learning depends on adequate design, features, and access systems, not just their availability.

Furthermore, the interviews uncovered that teachers are unfamiliar with the ARCS model and have never integrated it into their teaching. This is significant because the ARCS model theoretically emphasizes strategies to enhance attention, relevance, confidence, and learning satisfaction through structured instructional design. ARCS emphasizes that systematic and structured instructional design enables materials to be tailored for participatory learning, supports interactivity to enhance student engagement, and fosters the development of innovative digital

learning technologies (Chang et al., 2020). The absence of ARCS implementation presents an opportunity to introduce innovative, motivation-focused learning approaches by developing an ARCS-based e-module.

Teachers expressed a strong interest in developing an ARCS-based e-module. They believe that engaging digital teaching materials can help boost student motivation and interest in learning. The e-module format is seen as more aligned with current student learning habits, which tend to favor accessing information through digital devices. This aligns with findings by (Mafa & Govender, 2025) regarding educational technology adoption, which indicate that teachers and educators are more likely to use digital platforms when they perceive the system as easy to use, beneficial, and not excessively burdensome. Teachers also acknowledged that an e-module has significant potential to stimulate student attention and motivation by offering more dynamic, interactive learning experiences. This positive attitude also indicates strong support for developing teaching materials based on the ARCS model.

Regarding content, teachers emphasized the need for visuals, such as images and videos, to aid understanding of abstract Biology concepts. They also expect practice with feedback so students can independently assess and improve their comprehension. This indicates that teachers require not only visually appealing materials but also resources that facilitate self-assessment and concept reinforcement. This aligns with (Chen et al., 2025) and (Yorganci & Subaşı, 2025), who note that ARCS principles can be applied through various strategies such as animations, audiovisual aids, tests with feedback, and more.

Regarding infrastructure support, teachers reported that all students have smartphones and that the school provides Wi-Fi access. This environment strongly supports the implementation of the digital e-module. However, teachers also highlighted a potential challenge: network performance may degrade when many students use Wi-Fi simultaneously. Consistent with the findings of (Fitri et al., 2024), network or internet connectivity issues faced by students during learning significantly affect the effectiveness of the learning process. Although this is not a major obstacle, it should be considered in the e-module design process.

Overall, the school shows strong potential to adopt digital teaching materials, given user readiness, infrastructure support, and the need for more engaging and meaningful digital resources. Teachers also demonstrated high enthusiasm for developing an ARCS model-based e-module, given that this approach has not yet been applied and holds promise for enhancing student motivation and interest through improved learning experiences. These findings reinforce the urgency and relevance of developing an ARCS-based e-module to improve both motivation and the quality of Biology instruction.

Table 4. Student questionnaire results on learning and e-module preferences

Aspect	Percentage	
	Yes	No
Students hope that Biology learning will be easier to understand and more enjoyable.	94.9 %	5.1%
Students are satisfied with the current Biology instruction they receive.	72.2%	27.8%
Students need practice questions in Biology teaching materials to be engaging and interactive.	80.8%	19.2%

Students expect Biology teaching materials to be more engaging and enjoyable.	91.9%	8.1%
Students are interested in the Biology material presented as an electronic module (e-module).	72.2%	27.8%
Students are able to access the e-module on devices such as mobile phones or laptops.	87.9%	12.1%
Students have sufficient facilities, such as digital devices and internet access, to use the e-module.	83.3%	16.7%
Students are confident that engaging with the e-module helps them understand Biology more easily.	80.8%	19.2%
Students are interested in learning using an e-module.	72.7%	27.3%
Students hope the e-module includes interactive features like videos, quizzes, or animations.	90.4%	9.6%

The questionnaire results indicate that the majority of students have high expectations for improving the quality of Biology instruction. Specifically, 94.9% of students hope that Biology learning can become easier to understand and more enjoyable. This indicates that most students have very high expectations for improving the quality of Biology education. Although 72.2% of students feel satisfied with the instruction they currently receive, the higher percentage of expectations suggests that this satisfaction does not fully reflect the ideal learning experience they desire. The gap between satisfaction and expectations indicates that the current learning experience does not fully meet students' needs. Students want a learning experience that is more meaningful, engaging, and comprehensible. This finding aligns with the study by (Sutarto et al., 2020), which shows that students require teaching approaches that overcome boredom and increase engagement in learning.

Student preferences regarding teaching materials are also evident in the questionnaire results. Notably, 80.8% of students stated they need engaging, interactive practice questions, and 91.9% expect teaching materials to be more engaging and enjoyable. This demonstrates that students require not only informative content but also a learning experience rich in interaction, visualization, and independent activities. This is consistent with the findings of (Sulistiawati et al., 2025), which suggest that students often feel bored and struggle to understand material through conventional teaching, highlighting a significant need for interactive teaching materials. This finding emphasizes that the need for such materials is not merely a preference but a strategic necessity for comprehending Biology content. In this context, an e-module emerges as a potential solution that can be more appealing than conventional teaching materials.

Students' interest in using the e-module for learning is also quite high. Specifically, 72.2% of students are interested in having Biology material presented in an e-module and 72.7% expressed interest in learning through an e-module. This aligns with the findings of (Idayanti & Suleman, 2024), who observed that students demonstrate high enthusiasm and increased learning engagement when using e-modules. This reflects students' openness to technology-based learning innovations. Furthermore, 80.8% of students are confident that engaging with an e-module can help them understand Biology more easily, indicating that students recognize the potential of digital formats to enhance their understanding of material perceived as difficult. This finding aligns with research by (Lestari et al., 2025), which

demonstrates that an ARCS model-based e-module is effective in increasing student motivation and scientific argumentation skills in Biology.

Regarding facility readiness, the majority of students are in conditions that support the use of the e-module. Specifically, 87.9% stated they can access the e-module through digital devices, while 83.3% have adequate devices and internet access. The utilization of digital technology and the internet in education plays a significant role in expanding the scope of teaching and learning processes (Mhlongo et al., 2023). The availability of devices and internet connectivity is a crucial factor in ensuring that the e-module can be implemented without issues for most students. However, the existence of a small number of students with limited access highlights the need for design strategies or alternative approaches.

Student preference for e-module features is notably high. A significant 90.4% of students hope that the e-module includes interactive features such as videos, quizzes, or animations. This high percentage indicates that students desire a learning experience rich in visual and interactive elements. This is consistent with findings by (Abdulrahman et al., 2020) regarding the use of multimedia in learning, which support cognitive processing by integrating visual and auditory channels, thereby strengthening student engagement and understanding. These features also align with components of the ARCS model. Interactive elements can enhance Attention, provide Relevance through more contextual presentation of material, and support Confidence and Satisfaction by enabling independent learning, providing immediate feedback, and allowing students to experience a sense of accomplishment upon completing learning activities. The ARCS model emphasizes enhancing student attention, aligning learning materials with students' experiences, building self-confidence, and fostering satisfaction, which are essential to maintaining student motivation and ensuring that the learning process remains engaging, meaningful, and challenging (Wicaksono, 2025).

Overall, students demonstrate very high levels of readiness, need, and interest in using the e-module for Biology learning. The gap between satisfaction and expectation highlights the necessity for innovation in content delivery, particularly through teaching materials that support visualization, activities, and interaction. Student expectations for teaching materials that are engaging, interactive, and aid understanding form the foundation for developing an ARCS-based e-module for learning. Therefore, the development of an ARCS-based e-module is crucial to meet student expectations, enhance learning motivation, and more effectively support the understanding of complex and abstract Biology concepts.

D. CONCLUSION AND SUGGESTIONS

Biology education still requires teaching materials that can effectively motivate students and facilitate the understanding of abstract concepts. The findings of this study indicate that both teachers and students have a strong interest and need for an e-module as supplementary teaching material. Integrating the ARCS model into e-module development is considered promising for enhancing attention, relevance, confidence, and satisfaction in learning. This research confirms that an ARCS-based e-module can serve as a strategy to strengthen student motivation and learning experiences. The implications of this study give the potential to develop a more comprehensive and effective e-module.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to all parties who have contributed to the completion of this paper. Special appreciation is extended to the lecturers and academic supervisors for their valuable guidance, as well as to the respondents who participated in the study. Their support and cooperation were essential in completing this work.

REFERENCES

- Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia Tools in the Teaching and Learning Processes: A Systematic Review. In *Heliyon* (Vol. 6, Issue 11). Elsevier Ltd. <https://doi.org/10.1016/j.heliyon.2020.e05312>
- Amalia, Rasimin, & Yaksa, R. A. (2022). The relationship between learning motivation and students' independent learning in grade XI at SMA Negeri 11 Jambi City. *Jurnal Pendidikan Dan Konseling*, 4(6), 8189–8196.
- Annisa, I. (2025). The Impact of Scientific Visualization Quality on Visual Literacy and Conceptual Understanding in Biology. *Assimilation: Indonesian Journal of Biology Education*, 8(2), 217–230. <https://doi.org/10.17509/aijbe.v8i2.83556>
- Brophy, J. (2004). *Motivating Students to Learn* (2nd ed.). Lawrence Erlbaum Associates, Publishers.
- Cahyanto, B., & Afifulloh, M. (2020). Component Display Theory (CDT)-based electronic module (e-module) for integrated learning courses. *JINOTEPE (Jurnal Inovasi Teknologi Pembelajaran)*, 7(1), 49–56. <https://doi.org/10.17977/um031v7i12020p049>
- Chang, Y. S., Hu, K. J., Chiang, C., & Lugmayr, A. (2020). Applying mobile augmented reality (AR) to teach interior design students in layout plans: Evaluation of learning effectiveness based on the ARCS model of learning motivation theory. *Sensors*, 20(1). <https://doi.org/10.3390/s20010105>
- Chen, P. J., Liou, W. K., & Chen, M. J. (2025). Effects of An ARCS-based Interactive E-Book Featuring Clinical Scenarios on the Learning Motivation, Self-efficacy and Practical Competence of Nursing Students in Foetal Heart Rate Interpretation. *Nurse Education in Practice*, 83. <https://doi.org/10.1016/j.nepr.2025.104261>
- Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.
- Faristin, V. A., Ismanto, H. S., & Venty. (2023). Factors influencing high school students' learning motivation. *Jurnal UPGRIS*, 1(1), 125–153.
- Fitri, H., Himmawan, D., Wulandari, H., & Ardianti, I. (2024). Internet Connection Obstacles in General Speaking Courses and Their Influence on Learning Effectiveness. *Manajia: Journal of Education and Management*, 2(2), 28–35. <https://doi.org/10.58355/manajia.v2i2.21>
- Idayanti, Z., & Suleman, Muh. A. (2024). E-module as an independent learning material to improve student learning outcome. *Jurnal Penelitian Dan Pengembangan Pendidikan*, 8(1), 127–133. <https://doi.org/10.23887/jppp.v8i1.61283>
- Jääskä, E., Lehtinen, J., Kujala, J., & Kauppila, O. (2022). Game-based Learning and Students' Motivation in Project Management Education. *Project Leadership and Society*, 3. <https://doi.org/10.1016/j.plas.2022.100055>
- Kadluba, A., Reinhold, F., & Obersteiner, A. (2025). How Do Teachers Use Digital Technology in Classrooms? Characterizing Mathematics Teachers' Teaching Practices. *Computers and Education Open*, 1–16. <https://doi.org/10.1016/j.caeo.2025.100310>
- Keller, J. M. (2010). *Motivational Design for Learning and Performance: The ARCS Model Approach*. Springer.
- Kosasih, E. (2020). *Teaching material developmen*. PT Bumi Aksara.
- Lastri, Y. (2023). Development and utilization of e-module teaching materials in the learning process. *Jurnal Citra Pendidikan*, 3(3), 1139–1146. <https://doi.org/10.38048/jcp.v3i3.1914>

- Lestari, Y., Alberida, H., Helendra, H., & Anhar, A. (2025). Development of ARCS-based Biology E-Module to Enhance Students' Learning Motivation and Scientific Argumentation Skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 11(2), 611–624. <https://doi.org/10.22219/jpbi.v11i2.40869>
- Mafa, R. K., & Govender, D. W. (2025). Exploring Teachers' Technology Adoption: Linking TPACK Knowledge and UTAUT-3 Constructs. *Discover Education*, 4(1). <https://doi.org/10.1007/s44217-025-00480-z>
- Mhlongo, S., Mbatha, K., Ramatsetse, B., & Dlamini, R. (2023). Challenges, Opportunities, and Prospects of Adopting and Using Smart Digital Technologies in Learning Environments: An Iterative Review. *Heliyon*, 9(6). <https://doi.org/10.1016/j.heliyon.2023.e16348>
- Narpila, S. D., Pitaloka, D. D., Ramadhan, R., & Rusydi, A. M. (2025). Comparison of conventional learning and technology-based learning on student learning outcomes (a case study in class VIII A of SMP Cerdas Bangsa, Namorambe District, Deli Serdang Regency). *Jurnal Nakula: Pusat Ilmu Pendidikan, Bahasa Dan Ilmu Sosial*, 3(1). <https://doi.org/10.61132/nakula.v3i1.1501>
- Nisa, D. C., Purwidiani, N., Widagdo, A. K., & Astuti, N. (2024). Development of digital teaching materials using Flip PDF Corporate Edition for kitchen equipment materials in Phase E students. *Jurnal Ilmiah Profesi Pendidikan*, 9(3), 1655–1661. <https://doi.org/10.29303/jipp.v9i3.2468>
- Novibriawan, F. (2023). Literature review: E-learning as a learning resource and medium in the Merdeka Curriculum in elementary schools. *JSER Journal of Science and Education Research*, 2(2). <https://jurnal.insanmulia.or.id/index.php/jser/>
- Pua, M. Y. E., Setiawan, I. N. A. F., & Aristana, M. D. W. (2025). Interactive Content for High School Students in Bali with a Multimedia Graphic Design Approach. *Eduvest-Journal of Universal Studies*, 5(1), 142–151. <http://eduvest.greenvest.co.id>
- Rozali, A., Irianto, D. M., & Yuniarti, Y. (2022). Analysis of the problems of teacher-centered learning in student learning: A case study at SDN Dukuh, Sukabumi. *Journal of Elementary Education*, 05(01), 77–85.
- Sari, I. P. N., & Ferry, D. (2024). Analysis of students' learning difficulties in Biology subjects at senior high school. *BIOSFER: Jurnal Biologi Dan Pendidikan Biologi*, 9(2), 172–181.
- Suharni. (2021). Upaya Guru dalam Meningkatkan Motivasi Belajar Siswa (Teachers' efforts in improving students' learning motivation). *G-COUNS: Jurnal Bimbingan Dan Konseling*, 6(1), 172–184.
- Sulistiawati, D., Suryanti, & Hidayati, N. (2025). Survey of e-modules as Biology teaching materials in grade XI at SMAN 2 Siak Hulu. *Jurnal Review Pendidikan Dan Pengajaran*, 8(1).
- Sutarto, S., Sari, D. P., & Fathurrochman, I. (2020). Teacher strategies in online learning to increase students' interest in learning during COVID-19 pandemic. *Jurnal Konseling Dan Pendidikan*, 8(3), 129. <https://doi.org/10.29210/147800>
- Wicaksono, P. (2025). Learning Modules with ARCS Keller Approach to Increase Children's Learning Interest and Motivation. *Indonesian Journal of Islamic Elementary Education*, 5(2), 149–161.
- Yorganci, S., & Subaşı, M. (2025). Interactive GeoGebra applets to improving students' learning performance in e-book-based learning environment. *Education and Information Technologies*, 30(5), 5477–5500. <https://doi.org/10.1007/s10639-024-13021-2>
- Yulaika, N. F., Harti, H., & Sakti, N. C. (2020). Development of flipbook-based electronic teaching materials to improve student learning outcomes. *JPEKA: Jurnal Pendidikan Ekonomi, Manajemen Dan Keuangan*, 4(1), 67–76. <https://doi.org/10.26740/jpeka.v4n1.p67-76>