

Media Management Digital in Efforts to Improve the Quality of Biology Learning Education at Purnayudha High School, Labuhanbatu Regency

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Abstract

This study aims to examine how digital media management is implemented to improve the quality of biology learning at Purnayudha Senior High School, Labuhanbatu Regency. Specifically, the research explores the strategies used by the school in managing digital media, the supporting and inhibiting factors influencing its implementation, and its contribution to improving the quality of biology learning. A qualitative descriptive approach was employed, with data collected through classroom observations, semi-structured interviews, and document analysis. The participants consisted of the school principal, biology teachers, and students involved in digital-based learning activities. Data were analyzed using thematic analysis through coding, categorization, and interpretation of recurring patterns. The findings show that digital media management has been systematically integrated into curriculum planning and classroom instructional practices. The improvement in the quality of biology learning is reflected in several aspects, including increased student engagement in learning activities, more interactive classroom communication, improved access to learning resources, and better support for visualizing biological concepts through digital media. The effectiveness of this implementation is supported by internal factors such as collaboration among school leaders, teachers, and students, alignment between the school's vision and the integration of information technology, and the availability of technological facilities and infrastructure. External support is also provided by parents and partner institutions. However, challenges remain, particularly unstable internet connectivity and varying levels of digital competence among educators. To address these issues, the school continues to improve technological infrastructure and provide professional development programs to strengthen teachers' capacity in integrating digital media into biology learning.

KEYWORDS

Digital media management, biology learning, educational quality, school management.

Introduction

Education plays a fundamental role in developing individuals who are intellectually capable, morally grounded, and socially responsible. In Indonesia, the importance of education is emphasized in Law No. 20 of 2003 concerning the National Education System, which defines education as a deliberate and systematic effort to create learning environments that enable students to actively develop their potential. Through education, learners are expected to acquire not only knowledge and skills but also moral values, creativity, independence, and social responsibility necessary for participation in society; (N. Harahap et al., 2025; Lince, 2022) In the contemporary era, the rapid development of digital technology has significantly transformed various aspects of human life, including education. The emergence of the Industrial Revolution 4.0 has introduced new challenges for educational institutions, particularly in integrating information and communication technologies into teaching and learning processes (Indrasvari et al., 2021).

Among the three educational challenges identified by Panen, the accelerated development of technology stands out as a major concern (Jayadi & Harahap, 2023). The emergence of the Industrial Revolution 4.0 has transformed patterns of work and social interaction by introducing digitally oriented systems and practices. This transformation presents significant challenges for the education sector, particularly due to the existence of a “digital gap” between students and teachers. This gap relates to differences in technological understanding and digital proficiency. Consequently, educators are required to make substantial efforts to adapt, continuously update their competencies, and comprehend the ongoing developments in information technology within the context of the Industrial Revolution 4.0. (R. D. Harahap et al., 2025) Educational systems are now required to adapt to technological change by incorporating digital resources, innovative learning approaches, and technology-supported instructional practices. In this context, teachers are expected not only to facilitate knowledge transmission but also to guide students in navigating digital learning environments effectively (Maulana et al., 2022). The era of the Industrial Revolution poses significant challenges for education systems across the globe. As emphasized by Jack Ma during the 2018 World Economic Forum Annual Meeting, education constitutes one of the most significant challenges of the twenty-first century. He emphasized that without transforming current approaches to teaching and learning, society may encounter serious difficulties in the next three decades. An educational model that focuses predominantly on the transmission of knowledge while overlooking the development of attitudes and practical skills risks producing graduates who are unable to compete with increasingly advanced technologies and intelligent machines (Sperli, 2025). Educators serve as key agents of transformation within the educational ecosystem, acting as catalysts for meaningful change. Their role is essential in addressing fundamental aspects of education, including character formation, the cultivation of discipline, the reinforcement of national values, and the development of students’ moral integrity—responsibilities that fundamentally rely on the guidance and influence of teachers (Vidiyanti et al., 2025). The presence of machines or intelligent technologies will never fully substitute the role of human educators. Unlike robots, humans possess empathy and emotional depth. It is the teacher’s compassion and moral awareness that shape and nurture students, transforming their undeveloped potential into meaningful and admirable character. These formative spaces—referred to as morality and personality—can only be cultivated through genuine human interaction and guidance. (Winangsih & Harahap, 2023).

The greatness of a teacher will remain a driving force to give birth superior individuals, with character, with Indonesian personality (Maulana et al., 2022). Although a teacher in the industrial revolution era will never be replaced, the ability to master technological devices is a must. (R. D. Harahap & Hasibuan, 2025). In Indonesia, educators have progressively integrated technology as a complementary component of the instructional process, utilizing it both within classroom settings and in external learning environments. As a result, they are no longer constrained by time or place when preparing instructional materials for the following day’s lessons. In the era of the Internet of Things, educators can access information and obtain solutions rapidly by exploring various available educational links and digital resources, enabling more efficient and responsive lesson preparation (Perche et al., 2025). Teachers can utilize the internet to enrich their preparation by searching for relevant materials that make learning more engaging and meaningful. In this context, mastery of digital media becomes increasingly essential, and there is a growing need for teachers and students to possess comparable competencies in information

and communication technology (ICT) (Sun, 2025). The wide range of available learning applications should therefore be consistently introduced and promoted to educators. However, field realities indicate that technological proficiency remains uneven, with some teachers still having limited ability to operate digital devices effectively. Moreover, in many schools, inadequate facilities—such as the absence of LCD projectors and limited internet access—continue to pose significant challenges within the education sector (Nugroho et al., 2023).

In response to the educational challenges emerging in the era of the Industrial Revolution, the government has consistently implemented initiatives aimed at improving educational quality, particularly through the Ministry of National Education. These initiatives involve multiple stakeholders, with schools playing a central role as the government’s operational arm in implementing educational policies and programs at the institutional level (Sahasrabudhe & Kanungo, 2014). Quality is a state dynamic that associated with products, services, person, process, And the environment that reach or exceed hope (Sofyan et al., 2025). Circumstances dynamic that what is meant is refers to the fact that what is considered quality can and often does change as the law comes into effect. time and change condition environment (Xiao & Hew, 2024)

In macro factors, many factors influence the quality of education. (Wang et al., 2025). These determinants encompass various elements, including the curriculum, educational policies, and the availability of learning facilities (Kusuma et al., 2023). They also involve the integration of information technology or digital media in educational practices—particularly within teaching and learning activities—the implementation of innovative and contemporary instructional methods, strategies, and approaches, the use of appropriate evaluation systems, sufficient educational funding, professionally managed educational administration, and the presence of well-trained, knowledgeable, and competent human resources within the education sector (Parlindungan et al., 2020). These things in the world of small-scale education can summarized in management school.

School management constitutes a critical component in the organization of educational and instructional activities within schools, and its effectiveness is commonly evaluated based on the achievements and outcomes attained (Khattoon & Jones, 2022). Accordingly, effective leadership necessitates the functioning of a cohesive and well-coordinated system. In managing educational institutions, all interrelated elements—such as teachers, administrative personnel, students, parents, the wider community, government authorities, and other relevant stakeholders—are required to carry out their respective responsibilities effectively in order to ensure the successful attainment of educational objectives (Daryanes et al., 2023). That’s all function from A school can optimize his feelings in participate and improve quality education (Low et al., 2025).

One important strategy for responding to these challenges is the effective management of digital media in schools. Digital media management refers to the systematic planning, organization, implementation, and evaluation of digital technologies and learning resources used to support educational activities at the institutional level (Faccin & de Andrade, 2025). This concept goes beyond the simple use of digital tools in classrooms; it involves school-level governance practices that regulate how digital technologies are integrated into curriculum planning, instructional processes, and school information systems (Mägdefrau et al., 2025; Putri et al., 2023).

However, most previous studies primarily focus on the use of digital media in classroom instruction, rather than examining how digital media is systematically managed at the school level (Sperli, 2025) Limited research has explored how school leadership, institutional policies, infrastructure readiness, and stakeholder collaboration influence the successful implementation of digital media in educational institutions.

Furthermore, empirical studies that examine digital media management within specific subject areas—such as biology learning—remain relatively limited (Qun, 2025)

Biology learning presents unique challenges compared to other subjects because it often requires visualization of complex structures, processes, and phenomena that are difficult to observe directly. Digital media, such as multimedia presentations, simulations, and online learning platforms, can facilitate students' understanding of abstract biological concepts and enhance classroom interaction. Therefore, effective management of digital media becomes essential in supporting meaningful biology learning experiences (Bani Salameh et al., 2024).

Purnayudha Senior High School in Labuhanbatu Regency represents an interesting context for examining this issue because the school has actively integrated digital media into both its instructional activities and institutional information systems. The school has adopted various digital tools to support teaching and learning processes; however, the effectiveness of such implementation depends on how digital media are managed within the school ecosystem, including leadership support, teacher competence, technological infrastructure, and collaboration among stakeholders. Based on these considerations, this study aims to examine how digital media management is implemented as a strategy to improve the quality of biology learning at Purnayudha Senior High School, Labuhanbatu Regency. Specifically, the study explores the managerial practices involved in integrating digital media into the educational process, identifies the supporting and inhibiting factors influencing its implementation, and analyzes how such practices contribute to improving the quality of biology learning.

This research contributes to the literature by providing empirical insights into digital media management as a school-level governance practice, particularly in the context of biology learning. The findings are expected to offer a conceptual and practical understanding of how schools can strategically manage digital media to support more effective and meaningful learning processes in the digital era.

Methods

This study employed a descriptive qualitative approach to explore how digital media management is implemented to improve the quality of biology learning at Purnayudha Senior High School, Labuhanbatu Regency. A qualitative design was selected because it allows researchers to examine educational phenomena in depth and to understand participants' perspectives regarding the management and use of digital media in instructional practices. The research was conducted at Purnayudha Senior High School, Labuhanbatu Regency, Indonesia. The data collection process took place from May to July 2025, including the stages of preliminary observation, field data collection, and documentation review. Participants were selected using a purposive sampling technique, which allows researchers to select individuals who possess relevant knowledge and direct experience related to the research topic. The participants consisted of: 1 school principal, 2 biology teachers, 10 students involved in digital-based biology learning, 1 school committee representative, 1 school supervisor. These participants were chosen because they play important roles in the implementation and supervision of digital media use within the school's instructional activities.

Data Collection Techniques

Data were collected through interviews, classroom observations, and document analysis to obtain comprehensive information regarding the implementation of digital media management.

1. Interviews

Semi-structured interviews were conducted with the participants to explore their experiences and perspectives regarding digital media management in biology learning. The interview guide covered several themes, including: school policies related to digital media use, teachers' strategies in integrating digital media in biology learning, availability of digital infrastructure and learning facilities, supporting and inhibiting factors in digital media implementation, perceived impacts of digital media on learning quality.

2. Observations

Classroom observations were conducted during biology learning sessions to examine how digital media were utilized in instructional activities. The observations focused on: the types of digital media used in teaching, teacher-student interaction during digital learning activities, students' engagement and participation, classroom learning dynamics supported by digital media (Htun & Lim, 2025).

3. Document Analysis

Relevant documents were analyzed to support and validate the findings obtained from interviews and observations. These documents included: school curriculum documents, lesson plans (RPP) for biology learning, school policies related to digital technology use, photographs and records of digital learning activities (Fitriani et al., 2022).

Data Analysis

The collected data were analyzed using thematic analysis. The analysis process followed several stages:

1. Data reduction, which involved selecting, organizing, and simplifying relevant data obtained from interviews, observations, and documents.
2. Initial coding, where meaningful units of data were labeled to identify significant concepts related to digital media management.
3. Categorization, where similar codes were grouped into broader categories.
4. Theme development, where categories were interpreted to identify key themes explaining the implementation of digital media management in biology learning.
5. Conclusion drawing and verification, where the findings were interpreted and verified through continuous comparison of data sources.

Trustworthiness of Data

To ensure the credibility and trustworthiness of the research findings, several strategies were applied: Data triangulation, by comparing information obtained from interviews, observations, and documents. Source triangulation, by collecting perspectives from different participants including the principal, teachers, students, and school stakeholders. Member checking, where participants were given opportunities to confirm the accuracy of the interview results. Peer debriefing, where the researcher discussed findings with colleagues to minimize researcher bias.

Ethical Considerations

Ethical principles were applied throughout the research process. All participants were informed about the purpose of the study and voluntarily agreed to participate. Their identities were kept confidential to maintain anonymity, and all collected data were used solely for academic research purposes.

Result and Discussion

Digital Media Management in Improving the Quality of

Biology Learning at Purnayudha Senior High School

Based on data obtained from interviews, classroom observations, and document analysis, the implementation of digital media management at Purnayudha Senior High School can be understood through four main managerial functions: program planning, program organization, program implementation, and program monitoring and evaluation.

Program Planning

The planning of digital media integration is formally included in the school's annual work program and curriculum planning documents. The school integrates digital learning strategies into lesson plans (RPP) and instructional planning for biology subjects. Document analysis of several biology lesson plans shows that teachers explicitly include the use of digital media such as presentation software, online learning platforms, and multimedia learning materials to support classroom instruction (Kivuti et al., 2024). For example, one biology lesson plan analyzed in this study includes digital visualization media to explain cell structures and biological processes. This planning stage reflects the school's commitment to integrating technology into the learning process. As stated by the school principal during the interview:

"The use of digital media has been incorporated into the school's learning planning. Teachers are encouraged to integrate technology in lesson plans so that learning becomes more interactive and relevant to students' needs." (Principal Interview)

The integration of digital media in lesson planning indicates that technology use is not incidental but systematically designed as part of the instructional process.

Program Organization

The organization of digital media management involves establishing a coordination structure to manage digital learning activities within the school. The school formed a small team responsible for coordinating digital learning implementation, maintaining technological facilities, and assisting teachers in utilizing digital media in the classroom. Interview data indicate that the involvement of multiple stakeholders supports the implementation of the program. A biology teacher explained:

"The school provides technical support and training for teachers so that we can use digital media effectively in the classroom. If we face technical difficulties, the team assigned by the school helps us." (Biology Teacher Interview)

This organizational structure facilitates coordination between school leadership, teachers, and technical support staff in managing digital learning activities.

Program Implementation

The implementation of digital media management occurs through several activities, including teacher training, provision of technological infrastructure, and integration of digital media into classroom learning. Based on observation data during biology learning sessions, teachers utilized digital media such as presentation slides, instructional videos, and online learning platforms to explain complex biological concepts. The use of visual media helped students better understand abstract topics such as cellular structures and biological processes. Observation field notes indicate that students were more actively engaged during digital-based learning sessions:

"During the lesson, students showed high interest when the teacher used visual animations to explain cell division. Several students asked questions and actively participated in the discussion." (Observation Field Notes)

Students also reported that digital media made learning more interesting and easier to understand:

"Learning biology using videos and pictures makes it easier for us to understand the material compared to only reading from textbooks." (Student Interview)

These findings indicate that digital media contributes to creating a more interactive and engaging learning environment.

Program Monitoring and Evaluation

Monitoring and evaluation of digital media implementation are conducted through supervisory activities by the school principal and academic supervisors. These activities include classroom supervision and evaluation of lesson planning and instructional practices. Documentation analysis shows that supervision forms include indicators related to the use of learning media, classroom interaction, and student engagement.

According to the principal:

"Supervision is conducted to ensure that digital media are used effectively in teaching. We evaluate whether the media support learning objectives and improve students' understanding." (Principal Interview)

The evaluation process allows the school to continuously improve its digital learning practices and address challenges encountered during implementation.

Indicators of Improved Quality of Biology Learning

The improvement in the quality of biology learning observed in this study is reflected in several indicators: Increased student engagement during classroom activities, Improved visualization of complex biological concepts, More interactive teacher-student communication, Greater access to diverse learning resources through digital platforms.

These indicators were consistently identified across observation data, interview responses, and supporting documents.

The findings of this study indicate that the successful implementation of digital media management at Purnayudha Senior High School is closely related to several key factors, including leadership support, infrastructure readiness, teacher competence, and collaboration among stakeholders. From the perspective of Total Quality Management (TQM) in education, these findings demonstrate alignment with several core principles of quality management (Arlianti et al., 2025).

First, leadership commitment plays a central role in the successful implementation of digital media management. The school leadership integrates digital media strategies into institutional planning and provides policy support for technology-based learning. This finding supports previous studies emphasizing that leadership commitment is essential for successful educational innovation and quality improvement. Second, employee involvement, particularly teacher participation in training and professional development activities, contributes significantly to the effectiveness of digital media integration. Teachers are not merely implementers of policy but active participants in improving the quality of instructional practices through the adoption of digital learning strategies. Third, the availability of technological infrastructure supports the implementation of digital-based learning environments (Low et al., 2025). The provision of computer laboratories, internet access, and digital learning platforms enables teachers to deliver more interactive and engaging learning experiences. Fourth, stakeholder collaboration, including support from parents and the school community, strengthens the sustainability of the digitalization program. This collaboration reflects the systemic nature of educational quality improvement, which requires the involvement of multiple actors within the educational ecosystem.

These findings indicate that digital media management contributes to improving the quality of biology learning not only through the use of technological tools but also through systematic management practices at the institutional level (Wang et al., 2025). Effective digital transformation in schools

therefore requires not only technological resources but also structured governance, continuous professional development, and strong leadership commitment (Husna & Supriyadi, 2023).

Efforts to improve the quality of education with digital media management at Purnayudha High School, Labuhanbatu Regency among others

Efforts to improve the quality of education through digital media management at Purnayudha Senior High School in Labuhanbatu Regency are realized through various strategies that include aspects of human resources, infrastructure, funding, and student development (Sperli, 2025). In terms of educators and education personnel, the school actively holds seminars and workshops to improve digital media literacy and competence. These activities aim to broaden teachers' insights regarding the use of information technology in the learning process so that they are able to integrate digital media effectively and innovatively in the classroom (Banerjee et al., 2024).

In terms of facilities and infrastructure, schools are strengthening their technological infrastructure to support the implementation of digital-based learning. These measures include the provision of computer labs, learning studios, LCD and projector equipment, Wi-Fi networks, and the introduction and utilization of various online learning applications such as Google Classroom, Zoom, Google Meet, Webex, and Microsoft Teams. Providing these facilities is a crucial factor in creating a learning environment that adapts to technological developments (Rhamdan, 2024).

In terms of funding, the school collaborates with various strategic partners, including alumni and the surrounding community, to support the sustainability of the school's digitalization program. This partnership demonstrates collaboration between the school and the external environment in an effort to improve the quality of educational

services (Jovan et al., 2023). Furthermore, improving educational quality is also realized through optimal student development, both in academic and non-academic areas (Vos et al., 2025). This approach demonstrates that digital media management is oriented not only toward the use of technology but also toward developing students' overall potential.

Conclusion

This study examined the implementation of digital media management to improve the quality of biology learning at Purnayudha Senior High School, Labuhanbatu Regency. The findings indicate that digital media is managed through systematic managerial functions, including planning, organizing, implementation, and evaluation. The successful integration of digital media in biology learning is supported by leadership commitment, teacher competence development, and the availability of technological infrastructure, which together contribute to more interactive learning processes and increased student engagement. However, this study is limited to a single school context and relies primarily on qualitative data from interviews, observations, and documents. Therefore, the findings should be interpreted within this specific context and may not be fully generalizable to other educational settings. Practically, the study suggests that improving digital-based learning requires not only technological facilities but also structured management practices and continuous professional development for teachers. Future research is recommended to employ mixed-method approaches and involve multiple schools to further examine the relationship between digital media management and measurable indicators of biology learning quality (Çayr & Çalşkan, 2025).

References

- Arlianti, N., Marzal, J., Haris, M., & Hasibuan, E. (2025). *Navigating geometric thought: A classroom-based intervention using discovery-contextual strategies aligned with van Hiele's cognitive framework*. 16(02), 499–517. <https://doi.org/10.24042/ajpm.v16i1>
- Banerjee, A. K., Sensoy, A., Goodell, J. W., & Mahapatra, B. (2024). Impact of media hype and fake news on commodity futures prices: A deep learning approach over the COVID-19 period. *Finance Research Letters*, 59, 104658. <https://doi.org/https://doi.org/10.1016/j.frl.2023.104658>
- Bani Salameh, A. K., Malak, M. Z., El-Qireh, F. A., Alhussami, M., & El-hneiti, M. (2024). Effect of virtual reality simulation as a teaching strategy on nursing students' satisfaction, self-confidence, performance, and physiological measures in Jordan. *Teaching and Learning in Nursing*, 19(1), e235–e241. <https://doi.org/10.1016/j.teln.2023.11.005>
- Çayr, A., & Çalşkan, F. (2025). The relationship of media and technology use status and attitudes of nursing students with self-directed learning skills. *Nurse Education Today*, 148, 106634. <https://doi.org/10.1016/j.nedt.2025.106634>
- Daryanes, F., Darmadi, D., Fikri, K., & Sayuti, I. (2023). Heliyon The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, 9(4), e15082. <https://doi.org/10.1016/j.heliyon.2023.e15082>
- Faccin, H., & de Andrade, T. A. N. (2025). Textual analysis of teaching-learning evaluations in higher education: Deep learning and lexical investigation approaches. *Expert Systems with Applications*, 265, 125982. <https://doi.org/10.1016/j.eswa.2024.125982>
- Fitriani, F., Harahap, R. D., & Safitri, I. (2022). Analysis of barriers to the online biology learning process during the COVID-19 pandemic in public high schools. *Biologos Journal*, 5(1), 81. <https://doi.org/10.30821/biologos.v5i1.1328>
- Harahap, N., Hasibuan, R., & Harahap, R. D. (2025). *JANUARY 2025 The effect of project-based learning on improving students' science learning outcomes at private schools*. 9(2), 58–66.
- Harahap, R. D., Bangun, B., & Siregar, S. U. (2025). *The effectiveness of IMLO Biology media in enhancing students' learning motivation under the Merdeka Curriculum*. 8(2), 184–191.
- Harahap, R. D., & Hasibuan, R. (2025). *Efektivitas Penggunaan Media Sosial Tiktok Untuk Pembelajaran Biologi di SMA Negeri 1 Rantau Utara*. 13(2), 1200–1207.
- Htun, Z. W., & Lim, S. (2025). The coevolutionary dynamics between public school teachers' public service motivation and the formation of their policy discussion ties during the implementation of basic education reforms in Myanmar. *International Journal of Educational Development*, 118, 103378. <https://doi.org/10.1016/j.ijedudev.2025.103378>
- Husna, K., & Supriyadi, S. (2023). Peranan Manajemen Media Pembelajaran Untuk Meningkatkan Motivasi Belajar Siswa. *AL-MIKRAJ Jurnal Studi Islam Dan Humaniora (E-ISSN 2745-4584)*, 4(1), 981–990. <https://doi.org/10.37680/almikraj.v4i1.4273>
- Indrasvari, M., Harahap, R. D., & Harahap, D. A. (2021). Analysis of the Impact of Smartphone Use on Adolescent Social Interactions During COVID-19. *Jurnal Penelitian Pendidikan IPA*, 7(2), 167–172. <https://doi.org/10.29303/jppipa.v7i2.622>
- Jayadi, U., & Harahap, A. (2023). Educational landscape in Indonesia in 2023: Challenges and opportunities. *International Journal of Education and Digital Learning*, 2(2), 49–58. <https://doi.org/10.54443/ijedl.v2i2.266>
- Jovan, A. C., Pragantha, J., & Haris, D. A. (2023). Development of Endless Runner Game " UNTARUN " on Web Platform. *International Journal of Application on Sciences, Technology and Engineering (IJASTE)*, 1(2), 748–754.
- Khattoon, R., & Jones, E. (2022). Assessment & Evaluation in Higher Education Flipped small group classes and peer marking: incentives, student participation and performance in a quasi-experimental approach. *Assessment & Evaluation in Higher Education*, 0(0), 1–18. <https://doi.org/10.1080/02602938.2021.1981823>
- Kivuti, E. M., Kaburu, D., & Ogada, K. O. (2024). An interactive multimedia model for developing QOE-enhanced e-learning platforms. *International Journal of Web-Based Learning and Teaching Technologies*, 19(1). <https://doi.org/10.4018/IJWLTT.347662>
- Kusuma, I. K. N., Putu, N., Astuti, E., Numertayasa, I. W., & Made, N. (2023). Lesson study to improve student learning outcomes in the implementation of the independent curriculum. *JEAR*, 7(2), 192–200. <https://doi.org/10.23887/jear.v7i2.51318>
- Lince, L. (2022). Implementasi Kurikulum Merdeka untuk Meningkatkan Motivasi Belajar pada Sekolah Menengah Kejuruan Pusat Keunggulan. *Prosiding Seminar Nasional Fakultas Tarbiyah Dan Ilmu Keguruan IAIM Sinjai*, 1(1), 38–49. <https://doi.org/10.47435/sentikjar.v1i0.829>
- Low, D. Y. S., Ali, I., & Tang, S. Y. (2025). Improving Student Motivation and Learning in Chemical Engineering Education: A Case of Scanning Electron Microscopy with Virtual 3D Technology. *Education for Chemical Engineers*, 100498. <https://doi.org/https://doi.org/10.1016/j.eca.2025.100498>
- Mägdefrau, J., Wecker, C., Engelmann, K., Michler, A., Baumgartner, I., & Böhm, M. (2025). Task-specific situational interest and appropriate learning

- strategy use in history lessons: A cross-classified multilevel analysis. *Learning and Instruction*, 98, 102116. <https://doi.org/https://doi.org/10.1016/j.learninstruc.2025.102116>
- Maulana, I., Harahap, R. D., & Safitri, I. (2022). Use of learning media through technology for biology education students. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, 4(3), 282. <https://doi.org/10.20527/bino.v4i3.13418>
- Nugroho, I. R., Wilujeng, I., & Prasetyo, Z. K. (2023). Mobile Learning Research Trends in Indonesia : A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(8), 356–365. <https://doi.org/https://doi.org/10.29303/jppipa.v9i8.3073>
- Parlindungan, D. P., Mahardika, G. P., & Yulinar, D. (2020). Efektivitas Media Pembelajaran Berbasis Video Pembelajaran dalam Pembelajaran Jarak Jauh (PJJ) di SD Islam An-Nuriyah. *Prosiding Seminar Nasional Penelitian LPPM UMJ*, 1–8.
- Perche, L., Yennek, N., & Léger, L. (2025). Interest and mind wandering: How do individual and situational characteristics impact learning? *Learning and Motivation*, 92, 102177. <https://doi.org/https://doi.org/10.1016/j.lmot.2025.102177>
- Putri, D. R., Harahap, R. D., & Siregar, S. U. (2023). Difficulty analysis of biology education students in learning microteaching at Universitas Labuhanbatu. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, 5(2), 236. <https://doi.org/10.20527/bino.v5i2.15593>
- Qun, Y. (2025). Investigating the impact of immediate vs. delayed feedback timing on motivation and language learning outcomes in online education: Perspectives from Feedback Intervention Theory. *Learning and Motivation*, 90, 102132. <https://doi.org/https://doi.org/10.1016/j.lmot.2025.102132>
- Rhamdan, D. (2024). *Pengembangan Video Pembelajaran Berbasis Capcut Pada Materi Pernapasan Manusia*. 7(1), 56–74. <https://doi.org/10.31764/justek.vXIY.ZZZ>
- Sahasrabudhe, V., & Kanungo, S. (2014). Appropriate media choice for e-learning effectiveness: Role of learning domain and learning style. *Computers & Education*, 76, 237–249. <https://doi.org/https://doi.org/10.1016/j.compedu.2014.04.006>
- Sofyan, D., Puspitasari, N., & Maryani, S. (2025). Students ' Mathematical Literacy Skills Through Contextual Teaching and Learning and Problem-Based Learning Models. *Plusminus: Jurnal Pendidikan Matematika*, 5(February), 105–114. <https://doi.org/https://doi.org/10.31980/plusminus.v5i1.2619>
- Sperli, G. (2025). Community detection in Multimedia Social Networks using an attributed graph model. *Online Social Networks and Media*, 46(March), 100312. <https://doi.org/10.1016/j.osnem.2025.100312>
- Sun, J. (2025). The integration of virtual reality and augmented reality technology in immersive media art. *Systems and Soft Computing*, 200377. <https://doi.org/10.1016/j.sasc.2025.200377>
- Vidiyanti, C., Wonorahardjo, S., Koerniawan, M. D., & Mangkuto, R. A. (2025). Visual clarity of several learning media under different daylight-opening positions and areas based on students' performance and perception. *Building and Environment*, 281, 113201. <https://doi.org/https://doi.org/10.1016/j.buildenv.2025.113201>
- Vos, M., Petter-Mixk, E., & Collou, L. (2025). Development and validation of the learning culture scale for small- and medium-sized enterprises. *The Learning Organization*, 32(7), 74–93. <https://doi.org/10.1108/TLO-09-2024-0279>
- Wang, Q., He, R., Gong, Y., Ren, C., Sun, H., Huang, X., & Yin, Y. (2025). Diverse Teacher–Students for deep safe semi-supervised learning under class mismatch. *Neural Networks*, 187, 107336. <https://doi.org/https://doi.org/10.1016/j.neunet.2025.107336>
- Winangsih, E., & Harahap, R. D. (2023). Analisis Penggunaan Media Pembelajaran pada Muatan IPA di Sekolah Dasar. *Jurnal Basicedu*, 7(1), 452–461. <https://doi.org/10.31004/basicedu.v7i1.4433>
- Xiao, Y., & Hew, K. F. (2024). Personalized gamification versus one-size-fits-all gamification in fully online learning: Effects on student motivational, behavioral and cognitive outcomes. *Learning and Individual Differences*, 113, 102470. <https://doi.org/https://doi.org/10.1016/j.lindif.2024.102470>