e-ISSN 2549-7472
Edumatic: Jurnal Pendidikan Informatika
Volume 10, Issue 2, **490-499.**
https://e-journal.hamzanwadi.ac.id/index.php/edumatic
DOI: 10.29408/edumatic.v10i2.36346

Augmented Reality-Based Learning Media to Evaluate Independent Learning Experience: Evidence from Higher Education

Anang Anggono Lutfi [1,*], **Tigus Juni Betri** [1]

[1] Universitas Islam Negeri Raden Mas Said Surakarta, Indonesia
[*] Corresponding author: Anang Anggono Lutfi, Universitas Islam Negeri Raden Mas Said Surakarta, Indonesia
✉ anang.anggono@staff.uinsaid.ac.id

Received: 25 July 2026 | Revised: 03 August 2026 | Accepted: 27 August 2026 | Published: 29 August 2026

Abstract
Augmented reality (AR) has been increasingly used in education; however, its application has largely focused on classroom settings and primary or secondary education. However, evidence regarding the use of AR for independent learning in higher education remains limited. This study aimed to evaluate students' perceptions of AR-based learning media for independent practical learning. AR media, designed to simulate experiments on strong, weak, and non-electrolyte solutions, were developed using the ADDIE model. The quantitative evaluation involved 85 undergraduate students selected through convenience sampling methods. Six indicators were assessed using a five-point Likert-scale questionnaire: performance, user interface (UI), AR interaction, motivation, learning media preference, and interest. The results showed that UI achieved the highest mean score among the technical indicators (M = 3.91, SD = 0.89), while motivation obtained the highest score among the learning experience indicators (M = 3.80, SD = 0.96). Overall, students perceived AR-based learning media positively, particularly in terms of interface design and motivation for independent learning. These findings extend the application of AR from classroom-based instruction to independent practical learning in higher education, although they reflect students' perceptions rather than causal effects on learning outcomes.

Keywords: augmented reality; higher education; independent learning; practical learning; user experience

To cite this article: Lutfi, A. A., & Betri, T. J. (2026). Augmented Reality-Based Learning Media to Evaluate Independent Learning Experience: Evidence from Higher Education. *Edumatic: Jurnal Pendidikan Informatika*, *10*(2), 490–499. https://doi.org/10.29408/edumatic.v10i2.36346

INTRODUCTION

In higher education, the significance of independent learning has grown as students are increasingly required to assume more responsibility for their education outside of traditional classroom activities. This approach is evident in Indonesia's *Merdeka Belajar Kampus Merdeka* (MBKM) initiative, which promotes student engagement in educational experiences beyond standard classroom environments. According to Meyer (2008), independent learning involves students taking on more responsibility for their education while receiving suitable support from educators. Fellner (2026) recently highlighted that independent learning is not merely about learning without help; it also includes students' capacity to identify and make use of relevant support to build knowledge. Nonetheless, sustaining motivation and adjusting to new learning methods continue to be significant challenges in independent learning. For instance, Ingadóttir et al. (2026) discovered that while students could stay motivated, they often

faced difficulties in comprehending and implementing self-directed learning when encountering novel instructional methods.

Technology-enhanced learning offers opportunities to address educational challenges by fostering flexible, interactive, and student-centered learning environments. Juniati et al. (2026) identified independent learning as a significant personal resource linked to student engagement and satisfaction in higher education. Similarly, interactive learning media can promote active participation and enhance learning performance in self-paced learning environments (Putri et al., 2024). The role of technology is particularly pertinent in practical subjects, where students are required to comprehend theoretical concepts, observe processes, and conduct experiments. In chemistry education, practical activities often require visual representations and laboratory resources, which may not always be available during independent learning. Consequently, technology that provides interactive visualisation and simulation can serve as an alternative means of supporting practical learning outside traditional laboratory settings.

Augmented reality (AR) is a technology with significant potential to enhance learning experiences. By incorporating virtual elements into the real world, AR enables students to engage with digital models while remaining conscious of their actual environment. Chhina et al. (2026) noted that AR can transform and enhance educational settings without necessitating full immersion, which is typical of virtual reality. More generally, learning supported by technology has been linked to heightened engagement, creativity, and active involvement (Marini et al., 2026; Yao, 2025). In terms of AR, Bhat et al. (2025) found that mobile AR impacted student engagement, although its influence on learning outcomes was less clear. Nagi and Al-Fuhaidi (2024) also emphasised the potential of AR and virtual reality to boost engagement, motivation, satisfaction, and comfort in higher education. These insights indicate that AR might be particularly suitable for independent practical learning, as it allows students to individually access and explore digital simulations.

Previous studies have demonstrated the application of AR across various educational contexts. For instance, Maryam et al. (2026) developed an AR application based on Indonesian folklore to connect educational technology and cultural preservation. Setiawan et al. (2025) implemented AR-based multimedia flashcards to introduce local culture, while Putri et al. (2025) examined AR in physics learning. Positive applications of AR have also been reported in chemistry and other educational settings (D'souza et al., 2025; Romainor et al., 2022). Nevertheless, a considerable proportion of AR-based educational research in Indonesia has focused on primary and secondary education (Al-Khowarizmi et al., 2021; Bandaso et al., 2025; Harumy et al., 2025; Ningrum et al., 2025; Putri et al., 2025; Savitri et al., 2019). This concentration leaves the application of AR for independent learning in higher education comparatively less explored.

Another disparity related to the context and emphasis of AR evaluation exists beyond variations in educational attainment. Many existing studies have focused on AR within classroom instruction or explored its connection to conceptual understanding and other educational outcomes. However, there has been less focus on students' experiences when AR is utilised independently, especially for practical learning in higher education. This distinction is crucial because the effective independent use of AR relies not only on mastering content but also on technical aspects, such as application performance, interface design, and AR interaction. Additionally, students' motivation, media preferences, and interests are significant for comprehending how AR is viewed as a standalone learning tool. Therefore, assessing both the technical and experiential aspects can offer a more thorough insight into students' experiences with AR-based educational media.

Accordingly, this study aimed to evaluate students' perceptions of AR-based learning media for independent practical learning in higher education. The evaluation focused on two complementary dimensions. The first addressed the technical aspects of AR, including

application performance, user interface, and AR interaction, while the second examined the independent learning experience through motivation, learning media preference, and interest. By examining AR in an independent practical learning context among higher education students, this study extends previous research that has predominantly focused on classroom settings and lower educational levels. The findings are expected to provide empirical evidence regarding students' perceptions of AR-based independent learning and to identify aspects that should be considered when designing more adaptive learning media for higher education.

METHOD

This study employed a design and development research approach using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model to develop augmented reality (AR)-based learning media for independent practical learning in a Basic Chemistry course. Subsequently, a quantitative evaluation was conducted to examine students' perceptions of the technical aspects of the AR application and their independent learning experience.

This study involved 85 second-semester undergraduate students from the Informatics and Data Science study programs who were enrolled in a basic chemistry course. Participants were selected using convenience sampling because they were directly involved in the course in which the AR learning media were implemented. All participants had prior experience using mobile applications and completed all questionnaire items. The AR-based learning media were developed through the five stages of the ADDIE model. This model provides a systematic process from identifying learner needs to evaluating the developed media and has also been applied in previous AR-based learning media development (Maulana et al., 2024). The development procedure is presented in Figure 1.

Figure 1. Addie stages

Figure 1 illustrates the five stages of this study. The Analysis stage identified students' needs and preferences for learning media platforms and features. The Design stage translated these findings into a storyboard, defining the application structure and content. During Development, the AR media were created using Assemblr Edu with a marker-based approach and underwent alpha testing before implementation. The Implementation stage involved students independently using the AR application, while the evaluation stage assessed their perceptions of the technical aspects and independent learning experience.

During the analysis stage, a closed-ended needs analysis survey was administered to the students at the beginning of the semester. The findings were used to guide the design of the learning media. A storyboard was then developed to organise the app's structure, content, and presentation. The learning content consisted of simulations involving strong electrolytes, weak electrolytes, and non-electrolytes, in accordance with the Basic Chemistry semester lesson plan. The AR media were developed using Assemblr Edu with a marker-based approach to create the AR content. Alpha testing was conducted by the developers to identify technical problems before implementation. Students then used the application independently at their respective locations during a single learning session to explore virtual practical simulations of electrolyte solution.

Students' perceptions were evaluated using a questionnaire adapted from the Edufusion study by D'souza et al. (2025). The original 10 questions were adapted into six items according to the objectives of the present study. The technical dimension consisted of application performance and responsiveness, user interface design, and AR interaction, while the

independent learning experience dimension included motivation, learning media preference, and interest in using AR for learning. After using the AR application, participants completed a five-point Likert-scale questionnaire. Scores of 1–2 were categorized as negative, 3 as neutral, and 4–5 as positive responses.

RESULTS AND DISCUSSION

Results

The AR main menu presents an experimental display of strong, weak, and non-electrolyte solutions. Next, there is a menu that contains an explanation of what solutions include weak, strong, and non-electrolytic electrolytes. The augmented reality developed provides a virtual simulation of the experiment. Figure 2 shows the development of augmented reality-based learning media.

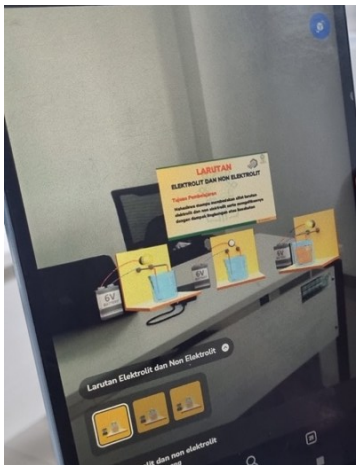

Figure 2. Augmented reality-based learning media

User needs analysis enables students to obtain learning media suited to independent learning needs. A technical evaluation of the AR application was conducted to ensure that it functions effectively during the learning process. An analysis of user needs and a technical evaluation of the AR application were prepared to support students readiness for independent learning. The respondents were second-year students from the Informatics and Data Science study programs who were taking the Basic Chemistry course. The respondents had prior experience using mobile applications, and all respondents answered every question.

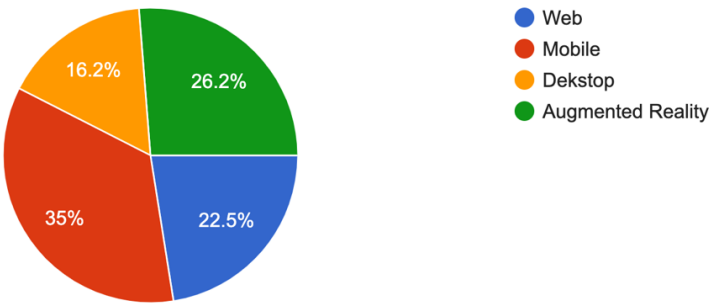

Figure 3. Learning media platform needs analysis diagram

User needs analysis is conducted by providing surveys to users. Conducting a user needs survey is essential to gain insight into the features that align with user requirements, thereby

enabling an optimal independent learning experience. The results of the needs analysis are shown in Figures 3 and 4. Mobile and augmented reality based platforms are the most desired learning media platforms by students. Material in the form of 2-dimensional and 3-dimensional images is a feature that users need. Visual images is more needed by students than material in the form of text.

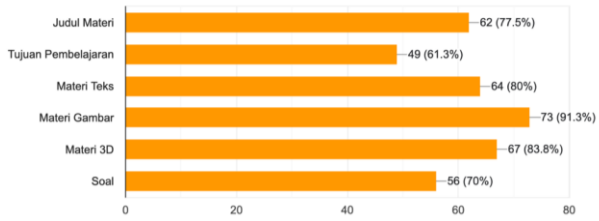

Figure 4. Learning media feature needs analysis diagram

The evaluation outcomes are illustrated in Figure 5. Concerning the performance indicator, 55.3% of users gave a positive rating, while 30.6% were neutral and 14.1% were negative. The positive feedback surpassed the total of neutral and negative responses. The application was utilised across a range of mobile devices owned by higher education students. Evaluating the design of the learning media interface is crucial, as the display is a significant component of an application. Positive feedback was given by 71.8% of users, with 20% remaining neutral and 8.2% expressing negative views. Students regard the user interface design of this application as effective. For the AR interaction indicator, 58.8% of users rated it positively, 18.8% were neutral, and 22.3% were negative. In higher education, students must be conscious of engaging in self-directed learning. Interactive learning media can enhance user comfort.

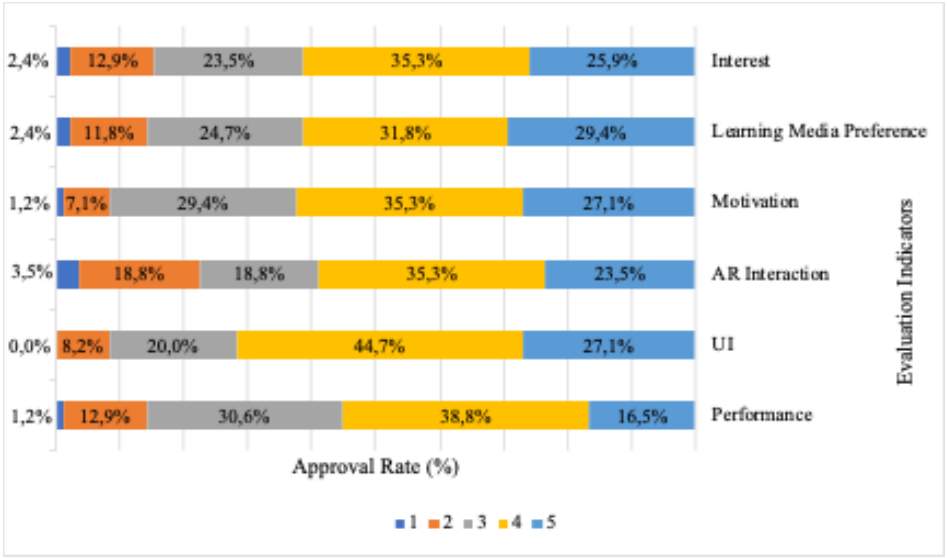

Figure 5. Approval rate of evaluation

Next, an evaluation was carried out regarding the impact of augmented reality on learning. A total of 62.4% of respondents expressed a positive attitude, stating that they were motivated to engage in independent learning using augmented reality learning media. A total of 29.4% rated it neutral, and 8.3% rated it negative. A total of 61.2% of respondents agreed that they preferred AR over textbooks. A total of 24.7% rated it neutral, and 14.2% rated it negative. Students in higher education also prefer to learn using augmented reality rather than

traditional books. As many as 61.2% of respondents stated that they are more interested in using augmented reality in learning. A total of 23.5% rated it neutral, and 15.3% rated it negative.

As shown in Table 1, all six indicators obtained mean scores above the neutral midpoint of 3.00, indicating generally positive student perceptions of the AR-based learning media. Within the AR application dimension, the user interface received the highest mean score (M = 3.91, SD = 0.89), whereas performance (M = 3.56, SD = 0.95) and AR interaction (M = 3.56, SD = 1.14) obtained identical mean scores. However, AR interaction showed the largest variability among the technical indicators, suggesting greater differences in students' perceptions of their interaction with the AR features.

In the dimension of independent learning experience, motivation achieved the highest average score (M = 3.80, SD = 0.96). This was followed by a preference for learning media (M = 3.74, SD = 1.08), and interest (M = 3.69, SD = 1.06). Despite having the lowest average score in this category, interest still surpassed the neutral midpoint. Overall, the descriptive findings suggest that the user interface and learning motivation were the most favourable elements of the AR-based independent learning experience.

Table 1. Descriptive statistics of AR evaluation indicators

Dimension	Indicator	Mean (M)	Standard Deviation (SD)
AR Application	Performance	3.56	0.95
	User Interface	3.91	0.89
	AR Interaction	3.56	1.14
Independent Learning Experience	Motivation	3.80	0.96
	Learning Media Preference	3.74	1.08
	Interest	3.69	1.06

Discussion

The results demonstrate that students generally held a positive perception of AR-based learning media across both the technical and independent learning experience dimensions. Each of the six indicators achieved mean scores exceeding the neutral midpoint, with the user interface (UI) attaining the highest score among the technical indicators and motivation receiving the highest score within the independent learning experience dimension. These findings imply that students' experiences with AR for independent practical learning are influenced not only by the availability of digital simulations but also by the quality of interaction with the learning environment. This pattern aligns with previous research, indicating that AR can facilitate positive learning experiences when technological and instructional features are effectively integrated (Nagi & Al-Fuhaidi, 2024; Prasetya et al., 2024).

Among the technical indicators, the user interface (UI) received the highest rating (M = 3.91, SD = 0.89), suggesting that students had a favourable reaction to the interface when using the app on their own. An easy-to-use interface can be crucial for independent learning, as students have less immediate support from instructors when navigating educational resources. Chhina et al. (2026) highlighted that AR can enhance current learning environments by merging virtual information with real-world settings without necessitating complete immersion in the virtual environment. In this scenario, a thoughtfully designed interface can facilitate more effective interaction with educational content, thereby supporting the adaptability needed in technology-enhanced independent learning (Juniati et al., 2026; Putri et al., 2024).

In contrast, AR interaction obtained the same mean score as application performance (M = 3.56) but showed the highest variability among the technical indicators (SD = 1.14). This pattern indicates greater differences in students' perceptions of their interactions with AR. D'souza et al. (2025) reported favourable responses to AR interaction in the Edufusion application, whereas the present study revealed more heterogeneous perceptions of AR interaction. Differences in application design and learning content may partly explain this pattern, as the present application primarily provides practical simulations. Nevertheless, this explanation remains tentative because different levels or types of AR interaction were not directly compared in this study. Marini et al. (2026) and Yao (2025) further emphasised that interactive and immersive characteristics remain important considerations in technology-supported learning environments.

Within the independent learning experience dimension, motivation achieved the highest mean score (M = 3.80, SD = 0.96). This result indicates that students generally perceive AR as a motivating medium for independent practical learning. Prasetya et al. (2024), through a meta-analysis of AR learning experiences, highlighted the relevance of motivational design for AR-supported learning. Similarly, Nagi and Al-Fuhaidi (2024) reported the potential of AR and virtual reality to support motivation, engagement, satisfaction, and learning comfort in higher education. The present findings extend this evidence to independent practical learning experiences. However, because motivation was measured through students' self-reported perceptions after a single learning session, the findings should not be interpreted as evidence that AR improves student motivation in general.

Mean scores for both learning media preference and interest were above the neutral midpoint, although interest had the lowest mean score within the learning experience category. This finding implies that while perceptions of AR are positive, they do not always translate into strong or lasting interest in its application. For example, Bhat et al. (2025) discovered that while mobile AR enhanced engagement, it did not lead to improvements in learning outcomes, highlighting the need to differentiate between technological engagement and educational effectiveness. Consequently, future AR development should focus not only on visual appeal but also on providing meaningful interaction, feedback, and learner-controlled activities to sustain student interest over time.

The results further build on earlier AR research by exploring its application for autonomous practical learning among university students. In Indonesia, Al-Khowarizmi et al. (2021), Bandaso et al. (2025), Ningrum et al. (2025), Putri et al. (2025), and Setiawan et al. (2025) demonstrated the use of AR predominantly in primary and secondary education settings, covering subjects such as science, informatics, physics, and cultural studies. For instance, Laurent and Maryani (2024) investigated the impact of AR on learning interest at the secondary school level. Conversely, this study revealed that university students also have favourable experiences when independently using AR for practical simulations. Practically speaking, the relatively high evaluation of the user interface and increased diversity in AR interactions indicate that future advancements should focus on maintaining interface usability while enhancing meaningful interactions through features such as feedback, learner-controlled exploration, or gamification.

Several limitations must be acknowledged when interpreting these findings. The generalisability of the results is restricted by the reliance on convenience sampling and the inclusion of participants from only two study programmes at a single institution. The assessment also focused on students' perceptions rather than objective learning outcomes. In addition, the absence of a control or comparison group limits the ability to determine whether AR provides superior learning experiences compared with traditional or other digital learning media. As the evaluation was conducted after only one independent learning session, it also remains unclear whether students' motivation, preferences, and interest would persist over

time. Future research should therefore incorporate more diverse samples, repeated or longitudinal AR use, validated evaluation instruments, and experimental or quasi-experimental designs to examine the relationship between AR-based independent practical learning and measurable learning outcomes.

CONCLUSION

Augmented reality offers an alternative approach to facilitate independent learning. It is crucial to highlight the primary finding of this research, which indicates that AR can enhance independent learning in higher education, with the user interface receiving the highest positive feedback as a technical component. The findings of this study broaden the understanding that augmented reality is not only applicable to classroom learning but also enhances the learning experience in self-directed learning. Augmented reality has played a role in boosting students' motivation for independent learning. The learning media examined in this study are currently restricted to materials featuring practicum simulations as their main component. Future research could expand augmented reality-based learning media by incorporating additional features such as gamification to enhance virtual interaction. Additionally, this study's limitations include the use of a convenience sampling method and the lack of a control group. Future studies should aim to address these limitations.

REFERENCES

Al-Khowarizmi, Akrim, & Ginting, N. (2021). The Model of Marker Based Tracking on the Augmented Reality of Hijaiyah Alphabet and Tajweed Al-Qur'an for Children Education. *2021 International Conference on Computer Science and Engineering (IC2SE)*, *1*, 1–4. IEEE. https://doi.org/10.1109/IC2SE52832.2021.9792135

Bandaso, R. M. S., Irwan, A. S., Azzahra, A. F., & Permana, F. (2025). Development of Augmented Reality (AR) Based Science Practice Application. In *2025 International Conference on Information Management and Technology (ICIMTech)* (pp. 596-601). IEEE. https://doi.org/10.1109/ICIMTech67074.2025.11264922

Bhat, K. R., Verma, V., & Craig, S. D. (2025). Mobile augmented reality impacts engagement, but not learning. Computers & Education: X Reality, 7, 100122. https://doi.org/10.1016/j.cexr.2025.100122

Chhina, A., Shah, S., Uribe-Marquez, S., Guruswamy, J., & Mitchell, J. D. (2026). Extended Reality (Augmented Realty, Virtual Reality, and Mixed Reality) in Teaching Technical Skills. *Anesthesiology Clinics*. https://doi.org/10.1016/j.anclin.2026.06.003

D'souza, L., Sawant, S., Pujari, N., Shetgaonkar, N., & Naik, P. (2025). EDUFUSION: Augmented reality for education. In *2025 5th International Conference on Soft Computing for Security Applications (ICSCSA)* (pp. 1789-1796). IEEE. https://doi.org/10.1109/ICSCSA66339.2025.11170769

Fellner, M. (2026). 'Independent learning'in higher education: examining the dynamics of autonomy and collaboration. *Journal of Further and Higher Education*, 1-18. https://doi.org/10.1080/0309877X.2026.2711358

Harumy, T. H. F., Ginting, D. S., Manik, F. Y., Yurliani, R., & Romli, A. (2025). Innovation Fadhera Apps based on Virtual Reality and Augmented Reality in STEAM Digital Literacy. In *2025 International Conference on Computing and Applied Informatics (ICCAI)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICCAI65301.2025.11279323

Ingadóttir, B., Schram, Á. B., Friðjónsdóttir, H. S., & Wentzel, J. A. (2026). Teaching communication and patient education in nursing: A case study grounded in self-regulated learning and motivation theory. *PEC innovation*, 100467. https://doi.org/10.1016/j.pecinn.2026.100467

Juniati, S., R, M., Jufri, J., Sakaria, S., & Setialaksana, W. (2026). Rethinking student well-

being in digital higher education: integrating self-directed learning and technological demands within the study demands–resources framework. *Asian Education and Development Studies*, *15*(3), 751–765. https://doi.org/10.1108/AEDS-12-2025-0726

Laurent, R., & Maryani. (2024). Analysis of the Influence of Students' Learning Interest on the Implementation of Augmented Reality in the Education System in Indonesia: A Case Study of High Schools in Tangerang City, Indonesia. In *2024 6th International Conference on Cybernetics and Intelligent System (ICORIS)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICORIS63540.2024.10903905

Marini, A., Muawanah, U., & Marfu, A. (2026). Enhancing critical thinking through problem-based learning: The role of student engagement and technology for education sustainability in Indonesia. *Sustainable Futures*, *11*, 101846. https://doi.org/10.1016/j.sftr.2026.101846

Maryam, N. S., Sugiharto, A. B., Herpristanti, N., & Maulana, F. I. (2026). Development of Augmented Reality Application from Maluku Folk Tale "Rusa Dan Kelomang" to Preserve Indonesia Culture. In *2026 20th International Conference on Ubiquitous Information Management and Communication (IMCOM)* (pp. 1-6). IEEE. https://doi.org/10.1109/IMCOM69009.2026.11360846

Maulana, F. I., Puspitasari, C., Hamim, M., Zaini, A., Arianto, F. F., & Rizky, R. D. (2024). Design and Development Immersive Learning Media Using Augmented Reality Technology to Preserve Barong Art. In *2024 International Conference on ICT for Smart Society (ICISS)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICISS62896.2024.10751297

Meyer, Bill. (2008). *Independent learning : literature review*. Dept. for Children, Schools and Families.

Nagi, G., & Al-Fuhaidi, B. (2024). Embedding Virtual and Augmented Reality in Higher Education in Yemeni Universities. In *2024 1st International Conference on Emerging Technologies for Dependable Internet of Things (ICETI)* (pp. 1-5). IEEE. https://doi.org/10.1109/ICETI63946.2024.10777175

Ningrum, G. D. K., Soraya, D. U., Nidhom, A. M., Anang, R. R. A., Afaf, R. S. H. T., Fadhlurrohman, M., & Fikriati, H. A. (2025). Implementation of Augmented Reality-Based Learning Media to Enhance Students' Conceptual Understanding and Learning Independence in Informatics Subjects. In *2025 9th International Conference On Electrical, Electronics And Information Engineering (ICEEIE)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICEEIE66203.2025.11253899

Prasetya, F., Fortuna, A., Samala, A. D., Rawas, S., Mystakidis, S., Wulansari, R. E., & Kassymova, G. K. (2024). The impact of augmented reality learning experiences based on the motivational design model: A meta-analysis. *Social Sciences & Humanities Open*, *10*, 100926. https://doi.org/10.1016/j.ssaho.2024.100926

Putri, D. A. P., Adi, C. N. S., & Sudarmilah, E. (2025). Evaluating the Impact of Augmented Reality on Physics Learning. In *2025 10th International Conference on Information and Communication Technology for the Muslim World (ICT4M)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICT4M68001.2025.11363510

Putri, N. K. S., Yuhana, U. L., Siahaan, D. O., & Alfian, M. (2024). Disrupting higher education: a comparative study of synchronous lecturing and self-paced learning in higher education. In *2024 2nd International Conference on Software Engineering and Information Technology (ICoSEIT)* (pp. 19-24). IEEE. https://doi.org/10.1109/ICoSEIT60086.2024.10497469

Romainor, N., Talib, C.A, & Aliyu, F. (2022). Augmented reality in chemistry education: A literature review of advantages on learners. *Journal of Natural Science and Integration*, *5*(1), 126-135. https://doi.org/10.24014/jnsi.v5i1.16805

Savitri, N., Aris, M. W., & Supianto, A. A. (2019). Augmented Reality Application for Science

Education on Animal Classification. *2019 International Conference on Sustainable Information Engineering and Technology (SIET)*, 270–275. https://doi.org/10.1109/SIET48054.2019.8986031

Setiawan, R. J., Ma'ruf, K., Hardila, S., & Mukhibun, A. (2025). Innovation in Educational Media: Development of Augmented Reality-Based Multimedia Flashcards for Introducing Yogyakarta's Local Culture. In *2025 3rd International Conference on Sustaining Heritage: The Future of Conservation: Embracing Technology and Innovation for Sustainable Heritage (ICSH)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICSH68040.2025.11548186

Yao, M. (2025). Innovative applications of multimedia technology in art and design education. *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, *20*(1), 1-14. https://doi.org/10.4018/IJWLTT.389873