



## The effectiveness of augmented reality-based e-modules in improving computer system learning outcomes

Vivi Gesilanda<sup>1</sup>, Nurkhamid<sup>2</sup>

<sup>1,2</sup>Universitas Negeri Yogyakarta, Kota Yogyakarta, Indonesia  
[vivigesilanda.2023@student.uny.ac.id](mailto:vivigesilanda.2023@student.uny.ac.id)<sup>1</sup>, [nurkhamid@uny.ac.id](mailto:nurkhamid@uny.ac.id)<sup>2</sup>

### ABSTRACT

Conventional learning on computer systems material in informatics often makes students passive, making it difficult for them to understand abstract concepts and leading to suboptimal learning outcomes. This study aims to analyze the effect of applying the Problem-Based Learning (PBL) model, assisted by Augmented Reality (AR), on the informatics learning outcomes of Grade 10 students. The research method used was a quasi-experiment with a pretest-posttest control group design. The sample consisted of several students divided into two groups: an experimental class that received the PBL-AR treatment and a control class that used conventional learning. Learning outcome tests were used as instruments, and data were analyzed using the N-Gain test after passing normality tests. The results showed a significant difference. The average posttest score of the experimental class significantly exceeded that of the control class, despite both groups having relatively comparable pretest scores. N-Gain analysis confirmed that the experimental class achieved improvement within the 'moderately effective' category, whereas the control class only reached the 'ineffective' category. It was concluded that the PBL model assisted by AR is significantly more effective in improving student learning outcomes on computer systems material. This innovative approach successfully increased active engagement and understanding of abstract concepts through interactive visualizations, thereby motivating students in the learning process.

### ARTICLE INFO

#### Article History:

Received: 1 Jul 2025  
Revised: 21 Oct 2025  
Accepted: 7 Nov 2025  
Publish online: 17 Nov 2025

#### Keywords:

AR; augmented reality; computer systems; learning outcomes

#### Open access

Inovasi Kurikulum is a peer-reviewed open-access journal.

### ABSTRAK

Pembelajaran konvensional pada materi sistem komputer informatika seringkali membuat murid pasif dan sulit memahami konsep abstrak, sehingga berdampak pada hasil belajar yang kurang optimal. Penelitian ini bertujuan menganalisis pengaruh penerapan model Problem Based Learning (PBL) berbantuan Augmented Reality (AR) terhadap hasil belajar informatika murid kelas X. Metode penelitian yang digunakan adalah kuasi-eksperimen dengan desain pretest-posttest control group. Sampel terdiri dari sejumlah murid yang dibagi menjadi dua kelompok: kelas eksperimen yang menerima perlakuan PBL-AR dan kelas kontrol yang menggunakan pembelajaran konvensional. Instrumen penelitian menggunakan tes hasil belajar, dan data dianalisis menggunakan uji N-Gain setelah lolos uji normalitas. Hasil penelitian menunjukkan perbedaan yang sangat signifikan. Rata-rata nilai posttest kelas eksperimen jauh melampaui kelas kontrol, setelah sebelumnya kedua kelompok memiliki nilai pretest yang relatif setara. Analisis N-Gain mengonfirmasi bahwa kelas eksperimen mencapai peningkatan dalam kategori cukup efektif, sedangkan kelas kontrol hanya mencapai kategori tidak efektif. Disimpulkan bahwa model PBL berbantuan AR secara signifikan lebih efektif meningkatkan hasil belajar murid pada materi sistem komputer. Pendekatan inovatif ini berhasil meningkatkan keterlibatan aktif dan pemahaman konsep abstrak melalui visualisasi interaktif, menjadikan murid lebih termotivasi dalam proses pembelajaran.

**Kata Kunci:** AR; hasil belajar; realitas ditambah; sistem komputer

### How to cite (APA 7)

Gesilanda, V., & Nurkhamid, N. (2025). The effectiveness of augmented reality-based e-modules in improving computer system learning outcomes. *Inovasi Kurikulum*, 22(4), 2382-2394.

### Peer review

This article has been peer-reviewed through the journal's standard double-blind peer review, where both the reviewers and authors are anonymised during review.



### Copyright

2025, Vivi Gesilanda, Nurkhamid. This an open-access is article distributed under the terms of the Creative Commons Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) <https://creativecommons.org/licenses/by-sa/4.0/>, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author, and source are credited. \*Corresponding author: [vivigesilanda.2023@student.uny.ac.id](mailto:vivigesilanda.2023@student.uny.ac.id)

## INTRODUCTION

Education aims to foster students' awareness to develop their potential, strengthen their intelligence, shape their character, instill noble morals, and equip them with skills that are useful to society, the nation, and the state, with teachers playing a key role in driving learning (Ramadhan *et al.*, 2021). The learning process includes planning and design that enable students to interact with teachers and various learning resources to achieve learning objectives. In the era of globalization and advances in information technology, opportunities to develop innovative learning through digital media are increasing. However, conventional methods such as lectures and question-and-answer sessions are still widely used, which tend to make students passive and reduce participation and learning outcomes (Handayani, 2023; Rosyiddin *et al.*, 2023). Therefore, the use of interactive teaching materials, such as e-books, journals, and e-modules, is important for enriching students' learning experience.

Based on the interview results, teachers reported that current methods tend to rely on one-way lectures without interactive media. As a result, students find it difficult to understand abstract concepts, such as computer system components and functions, due to a lack of clear visual representations. Teachers also reported that the limited availability of computer labs hinders students' ability to explore hardware directly. This shows that conventional methods are ineffective in helping students understand computer system concepts comprehensively because they fail to provide a realistic picture. As a result, students are suboptimal in the learning process.

Teachers play an important role in overcoming learning obstacles by selecting appropriate methods and media so that students can more easily understand the material and improve their learning outcomes. However, learning is still dominated by lectures, especially for computer systems material that requires visualization or simulation to explain relationships among components. Interactive visual media help students form mental representations of abstract concepts, whereas school media are still limited to printed books that are less interactive and do not display the details of system components (Abdulrahman *et al.*, 2020; Khaira *et al.*, 2023; Nugraheni & Ansori, 2025). These limitations call for innovative solutions, especially since students are already accustomed to using digital devices, even though they are still predominantly used for entertainment.

Learning outcomes are an important aspect of learning evaluation, but achieving learning outcomes does not depend only on the evaluation process. It is also influenced by the entire learning process, from planning and implementation to evaluation. Of these three aspects, the learning process plays the most significant role, as teachers' management of learning activities will largely determine students' understanding of concepts. For high school students, learning should be designed to be challenging and engaging, yet comfortable, so that it motivates them to think critically and explore complex concepts.

One approach to consider is the use of cooperative learning models. Cooperative learning models are considered effective in creating an active, collaborative, and enjoyable learning environment. In learning, students can collaborate, share ideas, and develop a deeper understanding of the subject matter. One proposed solution to overcome this obstacle is the use of technology, particularly Augmented Reality (AR) in the Problem-Based Learning (PBL) model, which can provide an interactive and visual learning experience. The use of AR effectively supports interactive learning, so that technology has great potential to improve student understanding and learning outcomes (Bahriah *et al.*, 2022).

The PBL model integrated with AR is an effective learning approach to improve students' cognitive processes and conceptual understanding (Chen *et al.*, 2025). The application of PBL makes the learning process more active and interactive, particularly when teachers deliver material on computer systems. Previous studies have shown that PBL can improve student learning outcomes in this material (Oktaviani *et al.*, 2025). As an additional innovation, this study incorporates game elements into quizzes and group

selection using the Wheel of Names and Kahoot websites to make the learning environment more enjoyable, stimulate enthusiasm, and increase students' active engagement. This approach is expected to serve as a reference for teachers to implement PBL-AR, which is not only engaging but also effective in improving student learning outcomes. This study aims to analyze the effect of AR in the PBL model on computer science learning outcomes, specifically on computer systems material.

## LITERATURE REVIEW

### **Augmented Reality (AR)**

Augmented Reality (AR) is a technology that combines the real world with virtual elements in two or three dimensions simultaneously. This technology enables more active interaction between students and learning materials by visualizing abstract concepts, making them easier to understand. AR utilizes a camera in real time to capture images while displaying visualizations that support student learning activities (Hasannah *et al.*, 2024; Pratama *et al.*, 2024; Ramadhan *et al.*, 2021). AR has specific characteristics, namely the simultaneous integration of real and virtual elements, real-time interaction, and the presentation of content in 3D form through hardware and software support (Ferrao *et al.*, 2023). In the context of education, AR can revolutionize conventional learning methods through 3D textbooks and interactive learning experiences that improve student understanding. AR is also useful in encouraging critical thinking and helping with everyday problem-solving (Jamilah *et al.*, 2024; Pringgar & Sujatmiko, 2020).

Technically, AR works with two main techniques, namely computer vision and pattern recognition. Computer vision is used to detect markers or visual markers, while pattern recognition functions to recognize visual patterns based on characteristics such as color, shape, and size. The combination of these two techniques allows physical objects to be accurately identified and then overlaid with digital elements such as animations, text, or three-dimensional models in real time, creating a more interactive and informative learning experience (Pramuditya *et al.*, 2022).

The success of AR in learning is demonstrated by increased student motivation, engagement, and understanding. AR creates an immersive learning experience that increases student engagement in the learning process (Hasannah *et al.*, 2024). 3D visualization has also been proven to aid in the understanding of abstract concepts and has an impact on improving academic learning outcomes and practical skills (Husna *et al.*, 2025). In addition, AR creates a learning environment that resembles real-life conditions, which strengthens students' memory of the material (Oktaviani *et al.*, 2025). In computer systems learning, AR is highly relevant because it overcomes the limitations of conventional media and provides real-time two- or three-dimensional visualizations that improve student understanding (Aristamy *et al.*, 2024; Hutahaeon *et al.*, 2023; Tassa & Hindarto, 2024).

### **Learning Module**

Modules are learning tools systematically designed to provide opportunities for independent learning, with teachers serving as facilitators. The learning process through modules involves structured planning, clear objectives, the provision of materials and instruments, and measurable assessment of student success (Sobah & Wardhani, 2022). The elements of a module include material, methods, limitations, and evaluation, with the main objective of encouraging students to learn independently without the direct involvement of teachers (Manzanillo, 2025; Yuni & Afriadi, 2020). Modules can function like teachers, so their composition needs to be communicative and appropriate to the maturity level of the students (Hasibuan, 2022). Modules can also overcome limitations of space, time, and sensory abilities so that independent learning can take place actively according to the individual's learning rhythm (Nugraha, 2023).

Technological developments have driven the transformation of modules into electronic modules, or e-modules. Electronic modules are understood as digital teaching materials that are structured into learning units, equipped with links, video tutorials, animations, and audio to increase student motivation and learning experience (Irmawati *et al.*, 202; Sholeh *et al.*, 2023). E-modules are flexible, easy to use, and capable of presenting objects or events that are difficult to observe directly (Ashary & Komara, 2023; Maivi *et al.*, 2021). E-modules have several key characteristics, including being self-instructional, self-contained, self-friendly, adaptive to technological developments, consistent in design, electronic media-based, and utilizing various software features (Rahayu *et al.*, 2022). With these characteristics, e-modules enable students to learn more independently and interactively.

### **The Role of Problem-Based Learning (PBL) Models in Augmented Reality (AR)**

The Problem-Based Learning (PBL) model places students at the center of the learning process by encouraging them to explore, observe, and solve problems in real-world contexts, particularly in STEM education (Munahefi *et al.*, 2023). The main advantage of PBL is its ability to improve conceptual understanding, as students are encouraged to independently search for, test, and develop ideas through discussion and group work. The integration of technology further strengthens the effectiveness of PBL, including Assemblr-assisted PBL, which utilizes AR. The use of AR in PBL creates a more dynamic and interactive learning environment, allowing students to work in groups with teacher guidance and helping to visualize abstract concepts into three-dimensional forms that are easier to understand.

Further research confirms that the application of AR-based PBL has a positive impact on student learning activities. This AR-based approach places students as the main subjects of learning so that they are more active in exploration and problem-solving (Ekayogi, 2023). Student responses to the use of AR have also been very positive, as this technology is considered practical, engaging, and supportive of scientific process skills and concept mastery compared with conventional methods. AR-based PBL not only strengthens students' understanding and learning outcomes of the material but also creates an enjoyable learning experience while increasing motivation, learning outcomes, and active involvement in the learning process.

### **Learning Theories Underlying the Development of AR-Assisted Learning Modules**

The development of learning media should be grounded in learning theories that provide guidelines to ensure effective implementation of the resulting products. Teachers, as facilitators, play an important role through teaching interactions that organize the learning environment to create an optimal teaching and learning process (Tambunan *et al.*, 2024). In the context of developing AR-assisted modules, behaviorist and cognitive theories are used as a foundation because both explain how students acquire, process, and reinforce understanding through interactive media (Ertmer & Newby, 2013).

Behaviorist theory emphasizes learning as a change in observable behavior through stimulus-response interactions with specific reinforcement (Yusra *et al.*, 2022). Its application in AR modules can take the form of positive and negative reinforcement, repeated practice opportunities, and rapid feedback. AR also facilitates role modeling, whereby students imitate the virtual objects displayed. In contrast, cognitive theory emphasizes learning as an active process in understanding and constructing knowledge (Kairu, 2021). Piaget highlights the importance of schemas, accommodation, and equilibrium in cognitive development, which in AR modules are evident in the systematic organization of information, PBL, and 3D visualization (Yusra *et al.*, 2022). Thus, integrating behaviorist and cognitive theories provides a strong

foundation for developing AR modules, as it complements students' needs for conceptual understanding while fostering meaningful learning experiences.

## METHODS

The type of research used was quasi-experimental research. According to Cook and Campbell in their book entitled "Quasi-experimentation," quasi-experiments are experiments that provide treatments, outcome measures, and experimental units. The subjects of this study were tenth-grade students selected using cluster random sampling. The selection was based on academic ability across classes, using prior student learning outcomes, resulting in one class as the experimental group and one as the control group, each comprising 35 students. This study examined the effect of using AR media within the PBL model on improving student learning outcomes in computer systems. This type of research aims to see the difference in the improvement of learning outcomes between students taught using the conventional learning model and students taught using the AR-based PBL learning model. In the research design in **Table 1**, there are two groups: one group given treatment, called the experimental group, and the other group not given treatment, called the control group. Both groups took pre- and posttests.

**Table 1.** Research Design

Group	Pretest	Treatment	Posttest
Control (K)	Y1	-	Y3
Experimental (E)	Y2	X	Y4

Source: Sugiyono in his book "Quantitative and Qualitative Research Methods and R&D"

Notes:

- K : Control group
- E : Experimental group
- Y1 : Control group *Pretest*
- Y2 : Experimental group *Pretest*
- : No treatment (conventional learning)
- X : Treatment with media augmented reality
- Y3 : Control group *Posttest*
- Y4 : Experimental group *Posttest*

This study uses quantitative data, specifically students' pretest and posttest results in computer science. The data were analyzed to examine students' work processes on the questions and to assess differences in learning outcomes following the application of the learning model. Before testing the hypothesis, data normality and homogeneity tests were conducted. Next, student scores were compared between the conditions before and after treatment, using both the conventional learning model and the AR-based PBL model. To calculate the gain, the following formula was used.

$$N - gain = \frac{\text{score post test} - \text{score pretest}}{\text{score ideal} - \text{score pretest}}$$

The *n-gain* score obtained from the calculation is then interpreted in **Table 2** as follows.

**Table 2.** N-Gain Criteria

Score	Criteria
>76%	Effective
75% - 56%	Quite effective
55% - 40%	Less effective

Score	Criteria
<40%	Not effective

Source: Sukarelawan et al. in the book "N-Gain VS Stacking (Analysis of Changes in Students' Abilities in a One-Group Pretest-Posttest Design)"

## RESULTS AND DISCUSSION

### Research Results

All 15 objective questions were declared valid based on the validity test results with an item-total correlation coefficient above 0.3 at a significance level of 5%. In addition, the pretest and posttest data of students in learning were tested for normality using the One Sample Kolmogorov Smirnov Test assisted by SPSS 25. The normality test was used to assess whether the data were normally distributed. The results of the normality test can be seen in **Table 3** below.

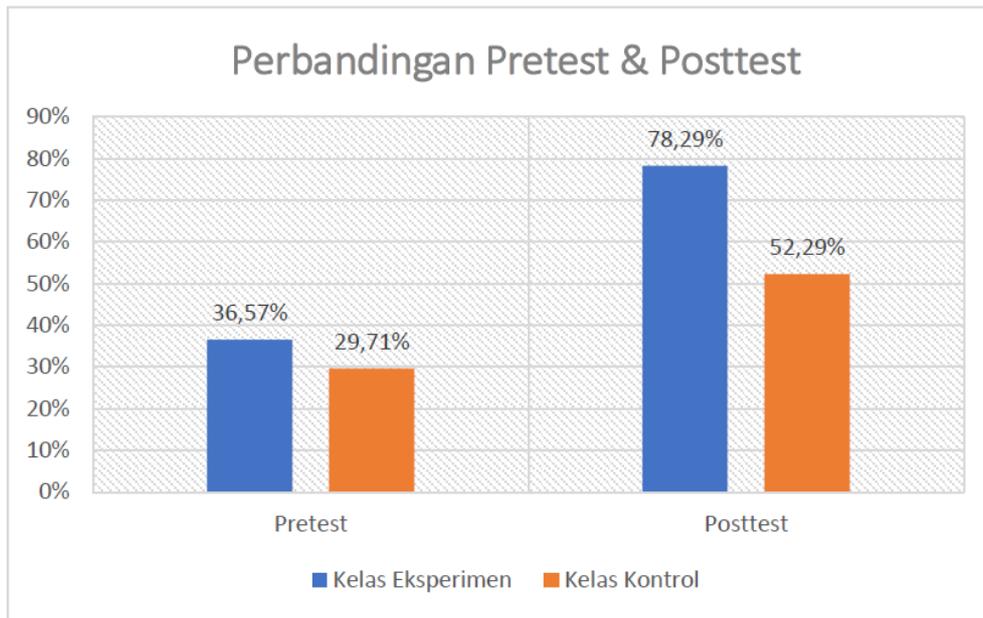
**Table 3.** Control and Experimental Class Normality Test Output using SPSS

### Tests of Normality

Kelas	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre_Eks	.142	35	.072	.941	35	.062
Post_Eks	.135	35	.104	.947	35	.091
Pre_Kontrol	.145	35	.059	.939	35	.053
Post_Kontrol	.143	35	.067	.946	35	.087
a. Lilliefors Significance Correction						

Source: Research (2025)

The test results using Kolmogorov Smirnov showed a significance value (sig.2-tailed) for the pretest in the experimental class of  $0.072 > 0.05$  and for the posttest in the experimental class of  $0.104 > 0.05$ . Meanwhile, the significance (sig.2-tailed) of the pretest in the control class was  $0.059 > 0.05$ , and the posttest in the control class was  $0.067 > 0.05$ . The significance of the pretest and posttest in both classes exceeded 0.05. This means that, when adjusted for the reference used for decision-making, the computer systems informatics learning outcomes for the control and experimental classes are normally distributed.



**Figure 1.** Comparison of Pretest-Posttest Results  
 Source: Research (2025)

The graph in **Figure 1** compares pretest and posttest scores for the control and experimental classes. The control class with conventional learning scored 29.71% on the pretest and 52.29% on the posttest. Meanwhile, the experimental class using media scored 36.57% on the pretest and 78.29% on the posttest. Thus, it can be said that the use of AR media are effective in improving student learning outcomes.

**Table 4.** Pre-test and Post-test Data for Control and Experimental Classes

**Descriptive Statistics**

	N	Minimum	Maximum	Mean	Std. Deviation
Pre_Eks	35	20.00	50.00	36.57	12.352
Post_Eks	35	40.00	90.00	78.29	14.243
Pre_Kontrol	35	10.00	40.00	29.71	10.977
Post_Kontrol	35	30.00	60.00	52.29	8.774
Valid N (listwise)	35				

Source: Research (2025)

Based on **Table 4** above, the average pretest score of the experimental class was 37 (36.57%), higher than that of the control class, which was 30 (29.71%). The average posttest score of the experimental class was 78 (78.29%), higher than that of the control class, which was 52 (52.29%). This indicates that AR is more effective and is further analyzed with N-gain.

**Table 5.** N-Gain Pretest and Posttest Calculation Results

		<b>Descriptives</b>		
	Kelas		Statistic	Std. Error
NGain_Persen	Eksperimen	Mean	65.9320	3.48306
		Median	75.0000	
		Std. Deviation	20.60607	
		Minimum	20.00	
		Maximum	87.50	
		Range	67.50	
	Kontrol	Mean	31.9615	1.92168
		Median	33.3333	
		Std. Deviation	11.36879	
		Minimum	14.29	
		Maximum	55.56	
		Range	41.27	

*Source: Research (2025)*

The N-gain results in **Table 5** show that learning with the AR-based cooperative method achieved 66% (considerably effective), whereas the conventional method achieved only 32% (ineffective). This confirms that AR media, using the PBL model, improve student learning outcomes through interactive visualization.

## Discussion

The study results indicate a significant difference in learning outcomes between students taught using the PBL model with AR support and those taught using conventional instruction. The analysis of the variables indicates significant results, indicating that the model improves the learning outcomes of Grade X students. Through learning activities that follow the syntax of the PBL model supported by AR, students become more motivated and enthusiastic in learning, which contributes to improved learning outcomes. Learning using media has a positive effect and can increase student motivation and learning outcomes (Lespita *et al.*, 2023). Studies also show that motivation and learning outcomes increase when implementing the PBL learning model with AR integration (Sulhaliza *et al.*, 2025).

The findings of this study also reinforce the results of previous studies showing that the application of the AR-assisted PBL learning model is effective in improving student learning outcomes (Sholikhah *et al.*, 2023). The advantage of the AR-based PBL model lies in the application of learning syntax, which requires active student involvement in identifying problems, finding solutions, and relating them to real-world experiences through interactive AR visualization. The syntax in the learning model used by researchers differs from that of other learning models. One of the distinguishing features of this study is the provision

of achievement-based rewards during the learning process. For high school students, this type of reward is still one of the factors that motivates learning, especially when tailored to the characteristics of adolescents who value recognition for their efforts and work results. This form of reward has been proven to increase students' intrinsic motivation and learning outcomes (Yolprezcky *et al.*, 2025).

This study is also supported by numerous relevant studies, including research that reveals that the implementation of this AR-based PBL model also provides opportunities for students to optimize their learning potential through active, collaborative, and student-centered learning experiences (Muhidin & Suparman, 2025). In addition, the integration of interactive visual technologies such as AR in the PBL learning model has been proven to improve students' critical thinking skills and learning outcomes at various levels of education (Nuraini *et al.*, 2024).

The results of data analysis using the AR-integrated PBL learning model had a very strong influence on student learning outcomes in informatics, especially in computer systems material. The average final score of students who learned using PBL-AR reached 78.29, much higher than the group who learned using conventional methods, which was only 52.29. This 26-point difference is statistically significant, indicating that the PBL-AR model is effective in deepening conceptual understanding and improving student learning outcomes in computer systems. These findings are also supported by previous research showing that the integration of AR in the PBL model consistently produces higher learning achievements compared to conventional methods (Afifah *et al.*, 2023).

## CONCLUSION

Based on the research results and discussion, it can be concluded that this study demonstrates that the implementation of an AR-based PBL learning model is an effective instructional approach to improving informatics learning outcomes of Grade X students in understanding computer systems material. Based on the findings, this study serves as a reference for teachers on the positive impact of integrating an AR-enhanced PBL model on students' informatics learning outcomes. Thus, learning is no longer teacher-centered but is oriented toward students' exploratory activities.

The recommendations that the researchers would like to convey in relation to this study indicate that the AR PBL learning model can improve student learning outcomes. Based on the results of this study, several suggestions can be made, namely: 1) teachers need to understand and master every syntax in the PBL learning model so that its implementation runs optimally; 2) the use of AR in e-modules needs to be designed in an attractive, interactive, and contextually appropriate manner to increase student motivation and engagement during the learning process; 3) Teachers are expected to be able to facilitate students who have difficulty understanding computer system concepts with a technology-based individual guidance approach. In addition, schools are expected to provide full support for the development and use of technology-based learning media, such as AR, to ensure the implementation of this innovation is sustainable. With support from all parties, the implementation of the AR-based PBL learning model can foster an active, innovative, and enjoyable learning environment and may improve student learning outcomes and conceptual understanding.

## REFERENCES

- Abdulrahaman, M. D., Faruk, N., Oloyede, A. A. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, 6(11), 1-14.
- Afifah, N., Koniyo, M. H., & Latief, M. (2023). Pengaruh model problem based learning terhadap hasil belajar siswa pada mata pelajaran Informatika SMK Negeri 1 Suwawa. *Inverted: Journal of Information Technology Education*, 3(1), 53-60.
- Aristamy, I. G. A. A. M., Dharsika, E., Iswardani, P. R., & Pascima, I. B. N. (2024). Pengenalan perangkat komputer pada siswa sekolah dasar menggunakan augmented reality. *Jurnal Pendidikan Teknologi dan Kejuruan*, 21(2), 101-112.
- Ashary, M. I. A., & Komara, D. A. (2022). Library human resources training through online-based service provider platform. *Edulib*, 12(1), 76-85.
- Bahriah, E. S., Agung, S., & Nur, A. I. (2022). Development of augmented reality technology-based interactive learning media in chemical bonding materials. *JCER (Journal of Chemistry Education Research)*, 6(2), 93-99.
- Chen, G., Wang, H., Liang, A., Oubibi, M., & Zhou, Y. (2025). From detached observer to immersive participant: An augmented reality-based experiential learning approach to promote academic performance and learning behaviors in science education. *Computers in Human Behavior Reports*, 19(1), 1-15.
- Ekayogi, I. W. (2023). Penerapan problem based learning berbantuan media augmented reality untuk meningkatkan hasil dan kemandirian belajar. *Jurnal Didaktika Pendidikan Dasar*, 7(1), 181-196.
- Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, 26(2), 43-71.
- Ferrao, J., Dias, P., Santos, B. S., & Oliveira, M. (2023). Environment-aware rendering and interaction in web-based augmented reality. *Journal of Imaging*, 9(3), 1-20.
- Handayani, F. (2023). Pengaruh metode ceramah dan tanya jawab terhadap minat belajar IPS murid SDN 1 SKPE SP1 Panjaitan. *Pema*, 2(3), 230-240.
- Hasannah, N., Afina, A. F., Nuraeni, P., & Hadiapurwa, A. (2024). Is education possible in the metaverse especially in Indonesia?. *Hipkin Journal of Educational Research*, 1(1), 13-24.
- Hasibuan, H. A. (2022). Peran modul berbasis kearifan lokal untuk mendukung pendidikan merdeka belajar. *Prosiding Pendidikan Dasar*, 1(1), 292-301.
- Husna, A., Risdiyanti, I., Yanto, Y., Hamidah, I., & Handican, R. (2025). Enhancing conceptual understanding and learning interest in geometry through augmented reality-based learning media. *JDIME: Journal of Development and Innovation in Mathematics Education*, 3(1), 11-21.
- Hutahaean, H. D., Ramadhan, L. N., Maulana, B., Silitonga, M., & Isnaini, M. (2023). Aplikasi pembelajaran perakitan komputer berbasis teknologi augmented reality. *Jurnal Teknologi Informasi dan Komunikasi dalam Pendidikan*, 10(1), 1-8.
- Irmawati, I., Baktiar, M., & Hutapea, B. (2023). Pemanfaatan e-modul bahan ajar berbasis aplikasi Canva pada prodi pendidikan Matematika dalam proses pembelajaran jarak jauh. *Jurnal Pendidikan Sains dan Komputer*, 3(1), 145-152.
- Jamilah, S., Rifani, S. A. C., & Hartono, R. (2024). Pengembangan media pembelajaran berbasis augmented reality materi perangkat keras pada mata pelajaran Informatika untuk meningkatkan hasil belajar siswa. *Jurnal Teknologi Pendidikan*, 13(2), 1-11.

- Kairu, C. (2021). Augmented reality and its influence on cognitive thinking in learning. *American Journal of Educational Research*, 9(8), 504-512.
- Khaira, H. S., Al Hafizh, M. F., Darmansyah, P. S. A., Nugraha, H., & Komara, D. A. (2023). Analysis of needs and teachers' perception towards business teaching materials at SMA Labschool UPI. *Curricula: Journal of Curriculum Development*, 2(2), 299-314.
- Lespita, E., Purwanto, A., & Syarkowi, A. (2023). Application of problem based learning model assisted by augmented reality media to improve students' high order thinking skills. *Jurnal Pendidikan Fisika*, 11(1), 1-12.
- Maivi, C. S., Ganefri, G., & Sukardi, S. (2021). Pengembangan e-modul berbasis android pada mata pelajaran Komputer dan Jaringan Dasar untuk kelas X TKJ di SMK N 2 Pekanbaru. *Informatika*, 9(1), 40-46.
- Manzanillo, R. M. (2025). Design and validation of an instructional module for business planning in the BS entrepreneurship program. *International Journal of Research and Innovation in Applied Science*, 10(3), 693-701.
- Muhidin, M., & Suparman, S. (2025). Penerapan model pembelajaran Problem Based Learning (PBL) untuk meningkatkan aktivitas dan hasil belajar Fisika siswa kelas XI SMA. *Jurnal Pendidikan MIPA*, 15(2), 871-877.
- Munahefi, D. N., Noverianto, B., Lestari, F. D., Maqfiroh, S. L., & Kartono, K. (2024). Problem based e-learning berbantuan Assemblr berbasis javanese culture augmented reality terhadap kemampuan spasial dan motivasi belajar. *Bookchapter Pendidikan Universitas Negeri Semarang*, 8(1), 71-89.
- Nugraha, A. (2023). Pemetaan pengembangan e-modul sebagai sumber belajar MIPA peserta didik. *Jurnal Jembatan Efektivitas Ilmu dan Akhlak Ahlussunah Wal Jama'ah*, 6(1), 14-21.
- Nugraheni, P., & Ansori, I. (2025). The hypercontent-based interactive multimedia in problem-based learning to improve Indonesian language learning outcomes of grade IV elementary school students. *Mimbar PGSD Undiksha*, 13(2), 267-278.
- Nuraini, S., Pranoto, A., & Ariani, D. (2024). Peningkatan hasil belajar materi teks argumentasi dengan menerapkan model Problem Based Learning (PBL) pada siswa kelas XI-5 SMA 6 Surabaya tahun ajaran 2024-2025. *Journal of Education and Pedagogy*, 1(2), 99-105.
- Oktaviani, E. B., Setyawati, E., & Wijayatningsih, T. D. (2025). Penerapan model Problem Based Learning (PBL) untuk meningkatkan hasil belajar siswa pada pembelajaran bahasa Inggris kelas X.8 SMA Negeri 11 Semarang. *Journal of Lesson Study in Teacher Education*, 4(1), 48-52.
- Pramuditya, S. A., Pitriyana, S., Subroto, T., & Wafiqoh, R. (2022). Implementation of augmented reality-assisted learning media on three-dimensional shapes. *Jurnal Elemen*, 8(2), 480-493.
- Pratama, A., Najril, M., & Khosyi, N. (2024). Towards technology-based education: Exploration of augmented reality in e-modules for latest learning. *Hipkin Journal of Educational Research*, 1(3), 351-362.
- Pringgar, R. F., & Sujatmiko, B. (2020). Penelitian kepustakaan (library research) modul pembelajaran berbasis augmented reality pada pembelajaran siswa. *IT-Edu: Jurnal Information Technology and Education*, 5(1), 317-329.
- Rahayu, D. S., Gunawan, Y. A. U., Fitriana, D. A., Sari, Y. A. S., & Ariska, W. S. (2022). Pengembangan prototipe e-modul matematika berorientasi HOTS pada materi transformasi geometri kelas IX. *Mathema Journal*, 4(1), 39-49.

- Ramadhan, A. F., Putra, A. D., & Surahman, A. (2021). Aplikasi pengenalan perangkat keras komputer berbasis android menggunakan Augmented Reality (AR). *Jurnal Teknologi dan Sistem Informasi*, 2(2), 24-31.
- Rosyiddin, A. A. Z., Fiqih, A., Nugraha, H., Hadiapurwa, A., & Komara, D. A. (2023). The effect of interactive PowerPoint media design on student learning interests. *Edcomtech: Jurnal Kajian Teknologi Pendidikan*, 8(1), 12-24.
- Sholeh, B., Hufad, A., & Fathurrohman, M. (2023). Pemanfaatan e-modul interaktif dalam pembelajaran mandiri sesuai kapasitas siswa. *Risalah Jurnal Pendidikan dan Studi Islam*, 9(2), 665-672.
- Sholikhah, U. P., Rahmawati, N. D., & Purwantini, L. (2023). Implementasi implementasi model problem based learning dengan media augmented reality terhadap hasil belajar siswa. *Eksponen*, 13(2), 57-65.
- Sobah, S. F. N., & Wardhani, I. Y. (2022). Pengembangan modul taksonomi tumbuhan sebagai bahan ajar materi Plantae pada pembelajaran Biologi SMA/MA. *Neuron: Journal of Biological Education*, 2(1), 33-43.
- Sulhaliza, A. P., Ermawati, D., & Setiawaty, R. (2025). Penerapan model PBL berbantuan media augmented reality terhadap kemampuan pemecahan masalah matematis siswa. *Absis: Mathematics Education Journal*, 7(1), 57-66.
- Tambunan, M., Wulandari, T., & Junior, D. D. (2024). Peran guru sebagai fasilitator dalam meningkatkan kemandirian belajar siswa sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 9(4), 393-402.
- Tassa, T. J. A., & Hindarto, H. (2024). Augmented reality mengubah pendidikan dasar: Era baru pembelajaran interaktif. *Indonesian Journal of Applied Technology*, 1(3), 1-17.
- Yolprezmzcky, S. O. D., Buditjahjanto, I. G. P. A., & Anifah, L. (2025). Pengembangan model PBL berbantuan augmented reality untuk meningkatkan pemahaman dan problem solving siswa. *Decode: Jurnal Pendidikan Teknologi Informasi*, 5(3), 863-872.
- Yuni, R., & Afriadi, R. (2020). Pengembangan modul pembelajaran kondisional untuk Belajar Dari Rumah (BDR). *Jurnal Handayam*, 11(2), 144-152.
- Yusra, A., Neviyarni, S., & Erianjoni, E. (2022). A review of behaviorist learning theory and its impact on the learning process in schools. *International Journal of Educational Dynamics*, 5(1), 81-91.