Jurnal Pendidikan dan Ilmu Fisika (JPIF)
Fakultas Pendidikan Islam dan Keguruan
Universitas Garut
p-ISSN: 2798-9488 e-ISSN: 2798-334X

Implementation of Augmented Reality (AR) Laboratory to Improve Students' Conceptual Understanding of Dynamic Electricity

Silpia Pirgianti[1], Ali Ismail[2*], Dini Andriani[1]

[1]Physics Education Study Program, Faculty of Applied Sciences
Institut Pendidikan Indonesia, Garut, Indonesia

[2]Elementary School Teacher Education Program
Universitas Pendidikan Indonesia, Sumedang, Indonesia

e-mail: ali_Ismail@upi.edu

DOI:
https://doi.org/10.52434/jpif.v6i2.44317

Accepted: August 8, 2026, Approved: August 10, 2026, Published: August 13, 2026

ABSTRACT

This study aims to determine the improvement and effectiveness of students' conceptual understanding of dynamic electricity through the implementation of an Augmented Reality (AR) Laboratory application. A quantitative approach with a quasi-experimental method was used, employing a non-equivalent control group design with two tenth-grade classes at SMK Negeri 2 Garut: an experimental class ($n = 26$) taught using the AR Laboratory application and a control class ($n = 24$) taught using a conventional problem-solving method. Conceptual understanding was measured using 12 validated and reliable essay items covering the indicators of interpreting, exemplifying, classifying, explaining, and inferring. Both classes showed an increase in mean score from pretest to posttest, with a significantly larger improvement in the experimental class (independent samples t-test, $p < .001$). The N-Gain analysis placed both classes in the moderate category, with the experimental class (0.54) higher than the control class (0.46), while the Cohen's d effect size of 0.99, moderate according to the classification used in this study, and approaching the threshold for a high effect indicates that 83.9% of the experimental group scored above the control group's average. These findings indicate that the AR Laboratory application produces a significantly greater improvement in students' conceptual understanding of dynamic electricity than conventional learning, and is a promising alternative for physics practicum instruction.

Keywords: *Augmented reality; conceptual understanding; dynamic electricity; quasi-experimental.*

Implementasi Augmented Reality (AR) Laboratory Terhadap Pemahaman Konsep Siswa Pada Materi Listrik Dinamis

ABSTRAK

Penelitian ini bertujuan untuk mengetahui peningkatan dan efektivitas pemahaman konsep siswa pada materi listrik dinamis melalui implementasi aplikasi Augmented Reality (AR) Laboratory. Penelitian menggunakan pendekatan kuantitatif dengan metode kuasi eksperimen, menggunakan desain non-equivalent control group pada dua kelas X di SMK Negeri 2 Garut: kelas eksperimen ($n = 26$) yang diajar menggunakan aplikasi AR Laboratory dan kelas kontrol ($n = 24$) yang diajar *menggunakan metode problem solving konvensional. Pemahaman konsep diukur menggunakan 12 butir soal esai yang telah diuji validitas dan reliabilitasnya, mencakup indikator menafsirkan, mencontohkan, mengklasifikasikan, menjelaskan, dan menyimpulkan. Kedua kelas menunjukkan peningkatan skor rata-rata dari pretest ke posttest, dengan peningkatan yang secara signifikan lebih besar pada kelas eksperimen (uji-t sampel independen, p < 0,001). Hasil analisis N-Gain menempatkan kedua kelas pada kategori sedang, dengan kelas eksperimen (0,54) lebih tinggi daripada kelas kontrol (0,46), sedangkan nilai effect size Cohen's d sebesar 0,99 — kategori sedang menurut kriteria yang digunakan dalam penelitian ini, dan mendekati ambang kategori tinggi — menunjukkan bahwa 83,9% siswa kelas eksperimen memperoleh skor di atas rata-rata kelas kontrol. Hasil ini menunjukkan bahwa aplikasi AR Laboratory memberikan peningkatan pemahaman konsep siswa pada materi listrik dinamis yang secara signifikan lebih besar dibandingkan pembelajaran konvensional, dan merupakan alternatif yang menjanjikan untuk pembelajaran praktikum fisika.*

Kata kunci: *Augmented reality; pemahaman konsep; listrik dinamis; kuasi eksperimen.*

INTRODUCTION

Physics is a branch of science that has a profound influence on the development of technology and natural science. However, physics is one of the subjects that most senior high school students find difficult to understand (Khumaidi & Sucahyo, 2018), largely because it contains many abstract concepts. Dynamic electricity is considered particularly difficult material, especially because it requires understanding the flow of electric current, which cannot be observed directly. Based on classroom observations, many students experience difficulty understanding the abstract, microscopic-scale concepts within dynamic electricity, making it hard for them to visualize the material and connect the theory with real-world phenomena. This difficulty contributes to low learning achievement, particularly in the aspect of conceptual understanding. This is consistent with research by Ni'mah and Widodo (2022), who found that students' ability to understand concepts remains relatively low, particularly regarding dynamic electricity. The causes of students' low understanding of electrical concepts include: (1) the large number of formulas involved, which confuses students; (2) students tend to be passive because learning is dominated by the teacher; and (3) the abstract nature of the material. Research by Hasbi (2015) further shows that dynamic electricity material is abstract and complex, while laboratory facilities are often limited, resulting in infrequent practicum activities and, consequently, low learning outcomes.

Based on Bloom's taxonomy, conceptual understanding falls within the second cognitive domain level (C2), which is crucial in the learning process because it represents the stage of comprehending abstract information by classifying objects or phenomena (Sari, 2018). This study specifically targets the C2 level because it functions as the foundation on which higher-order cognitive abilities depend: students who have not yet interpreted, exemplified, classified, and explained a concept in their own words are unlikely to apply, analyze, or evaluate it correctly at the higher C3-C6 levels (Anderson et al., 2001). Given that classroom observations and prior research (Ni'mah & Widodo, 2022) indicate that students' conceptual understanding of dynamic electricity is already weak at this foundational level, strengthening C2 is a necessary first step before more advanced instructional goals for this topic can realistically be pursued. Low conceptual understanding among students therefore makes it difficult for them to achieve higher-

Jurnal Pendidikan dan Ilmu Fisika (JPIF)
Vol. 06; No. 02; 2026; 210-219

order cognitive abilities, and learning strategies must be carefully designed to build on students' conceptual knowledge (Mubarrok & Mulyaningsih, 2014).

One learning medium that can help students understand the material they are learning more easily is Augmented Reality (AR). Augmented Reality is a visual technology that projects computer-generated information onto the user's view and can integrate a virtual environment to appear real, or display 3D virtual objects (Cai et al., 2017). AR can therefore be understood as a real object shown in real time together with a virtual object that appears when a device is applied to the real object with the help of a camera (Siahaan et al., 2019). Endarto and Martadi (2022) argue that AR presents new opportunities to facilitate the teaching and learning process, particularly in illustrating abstract concepts, while Nugroho (2023) notes that implementing augmented reality in learning spaces has the potential to enhance the learning experience and bring about significant changes in how students learn.

The pedagogical rationale for expecting AR to support conceptual understanding, rather than merely engagement, rests on how it manages the cognitive demands of learning abstract material. According to the spatial contiguity principle within the cognitive theory of multimedia learning, presenting related visual and symbolic information close together in space reduces the extraneous cognitive load required to mentally integrate them, freeing cognitive resources for the deeper processing needed to form an accurate mental model (Mayer, 2021). By overlaying a dynamically generated 3D visualization of current flow directly onto the physical circuit components students are manipulating, an AR Laboratory applies this principle concretely: it removes the need for students to mentally translate between an abstract symbolic representation (a circuit diagram or formula) and the invisible, microscopic-scale phenomenon it describes. This mechanism is consistent with systematic reviews reporting that AR supports STEM learning by improving spatial ability, practical skills, and conceptual understanding through this kind of complementary, co-located visualization (Ibáñez & Delgado-Kloos, 2018), and, specifically in physics education, by optimizing cognitive load and allowing students to observe and manipulate phenomena that would otherwise remain imperceptible (Vidak, Movre Šapić, Mešić, & Gomzi, 2023).

The use of Augmented Reality is further supported by several studies showing that this learning medium is effective when applied in the learning process (Dewi & Anggaryani, 2020). AR has been shown to be effective in helping students understand complex and abstract material by presenting content in 3D and animated forms that can be explored from various viewpoints. In addition, AR technology facilitates flexibility in teaching methods, enabling teachers to distribute instructional elements that suit students' learning styles (Hermawan & Hadi, 2024).

Despite this evidence, AR-based practicum applications for dynamic electricity remain comparatively unexplored: most published AR physics studies in the Indonesian context have focused on optics or magnetic fields (e.g., Dewi & Anggaryani, 2020; Cai et al., 2017), and it remains unclear whether the same benefits extend to the specific reasoning demands of current flow in circuits, which — unlike optical phenomena — cannot be observed even indirectly through light or motion. This study therefore aims to examine the implementation of an AR Laboratory application on students' conceptual understanding of dynamic electricity, comparing its effectiveness against conventional problem-solving instruction to determine whether this specific pedagogical gap can be addressed.

METHOD

This study used a quantitative approach with a quasi-experimental method. Quasi-experimental research involves treatment, impact measurement, and experimental units, but does not use random assignment to establish comparisons for inferring treatment-induced change (Abraham & Supriyati, 2022). The design used was a non-equivalent control group design, consisting of an experimental group receiving treatment with the AR Laboratory application and a control group receiving conventional learning without AR, as presented in Table 1.

Table 1. Non-equivalent control group design (adapted from Sugiyono, 2013)

Group	Design	Treatment	Pretest	Posttest
Experimental	O1 X1 O2	X1	Yes	Yes
Control	O3 X2 O4	X2	Yes	Yes

The independent variable in this study was the AR Laboratory learning media, while the dependent variable was students' conceptual understanding of dynamic electricity, focusing on the C2 (understanding) cognitive domain with the indicators of interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (Anderson et al., 2001).

Population and Sample

The population of this study consisted of all tenth-grade students at SMK Negeri 2 Garut in the 2025 academic year. The sample consisted of two classes from the Electrical Engineering department: Class X Electrical Engineering 3 as the control class (n = 24), taught using a conventional problem-solving method, and Class X Electrical Engineering 4 as the experimental class (n = 26), taught using the AR Laboratory application.

Research Instrument

The instrument used was a conceptual understanding test in the form of essay questions, developed based on the conceptual understanding indicators of Anderson et al. (2001), together with supporting learning tools such as the Lesson Plan (RPP), Student Worksheet (LKPD), and the test blueprint. The instrument was validated by an expert lecturer, and was tested for validity and reliability on a trial sample of 21 students at SMK 1 Juli prior to use in the main study.

Validity testing using SPSS Statistics 27 showed that all items were valid, with significant correlation values at the 0.05 and 0.01 levels. Of the original items tested, 12 items were retained for the main instrument. Reliability testing yielded a Cronbach's Alpha coefficient of 0.794, indicating high reliability (≥ 0.70) according to Arikunto (2009). Item difficulty analysis showed that 11 items fell into the easy category (index > 0.70) and one item fell into the moderate category (index 0.30-0.70). Item discrimination analysis using the Corrected Item-Total Correlation (CITC) showed values ranging from 0.308 to 0.622, with seven items in the good category and five items in the fair category, indicating that the instrument was able to effectively distinguish between students with high and low understanding.

Data Analysis Technique

Data analysis began with a normality test using the Shapiro-Wilk technique via SPSS Statistics 27, with data considered normally distributed if the significance value exceeded 0.05 (Arifin, 2017). This was followed by a homogeneity test using Levene's statistic, with data considered homogeneous if the significance value exceeded 0.05 (Trihendradi, 2019). If the data were normally distributed, hypothesis testing proceeded using an independent samples t-test, with the decision rule that a significance value (2-tailed) below 0.05 leads to rejection of the null hypothesis.

The magnitude of improvement in students' conceptual understanding was measured using the N-Gain test, calculated as N-Gain = (posttest score - pretest score) / (maximum score - pretest score), with the resulting score interpreted according to the criteria proposed by Hake (1999): high ($g > 0.7$), moderate ($0.3 < g < 0.7$), and low ($g \leq 0.3$). The magnitude of the treatment effect was further measured using Cohen's d effect size, interpreted according to the criteria of Cohen, Manion, and Morrison (2018): weak (0.00-0.20), low (0.21-0.50), moderate (0.51-1.00), and high (> 1.00). Note that this four-level classification differs from Cohen's (1988) original three-level convention (small ≈ 0.20, medium ≈ 0.50, large ≈ 0.80); the term 'moderate' used throughout this study refers to the former, broader classification, under which a d value approaching 1.00 already indicates a fairly substantial, near-high, practical effect — a distinction made explicit here to avoid ambiguity in the interpretation reported below.

RESULT AND DISCUSSION

Results

Descriptive statistics for the pretest and posttest scores of the control and experimental classes are presented in Table 2.

Table 2. Descriptive statistics of pretest and posttest scores for the control and experimental classes

Statistic	Control (pretest)	Control (posttest)	Experimental (pretest)	Experimental (posttest)
N	24	24	26	26
Minimum	3	8	6	17
Maximum	19	35	23	38
Mean	8.88	22.92	16.20	29.12

Both classes showed an increase in mean score after treatment, with the control class increasing from 8.88 to 22.92 and the experimental class increasing from 16.20 to 29.12. Although the experimental class already had a higher pretest mean, the increase observed in the experimental class was numerically larger, suggesting a stronger effect from the AR Laboratory treatment.

The Shapiro-Wilk normality test showed that all four data sets were normally distributed, with significance values of 0.193 (control pretest), 0.073 (control post-test), 0.143 (experimental pretest), and 0.586 (experimental post-test), all exceeding 0.05. The Levene's test for homogeneity, however, yielded a Based on Mean significance value of 0.013 (< 0.05), indicating that the variances of the two groups were not homogeneous. Consequently, the independent samples t-test was interpreted using the 'equal variances not assumed' row.

The t-test on the pretest scores showed t = 5.904, df = 47.585, and a significance value (2-tailed) of less than 0.001, indicating that the two groups already differed significantly before treatment. The t-test on the post-test scores likewise showed a significance value (2-tailed) of less than 0.001, which is smaller than the 0.05 significance level, so the null hypothesis was rejected. This indicates a significant difference in conceptual understanding between the experimental and control classes after treatment.

The N-Gain analysis, summarized in Table 3, showed that the control class achieved a mean N-Gain of 0.4577 (moderate category), with a minimum of 0.03 (low) and a maximum of 0.80 (high), while the experimental class achieved a mean N-Gain of 0.5433 (moderate category), with a minimum of 0.18 (low) and a maximum of 0.89 (high).

Table 3. N-Gain results for the control and experimental classes

Statistic	Control class N-Gain	Experimental class N-Gain
Mean	0.4577 (moderate)	0.5433 (moderate)
Minimum	0.03 (low)	0.18 (low)
Maximum	0.80 (high)	0.89 (high)

In terms of category distribution, the control class had 5 students in the low category, 16 in the moderate category, and 3 in the high category, while the experimental class had 4 students in the low category, 19 in the moderate category, and 3 in the high category. Although both classes fell into the moderate category overall, the experimental class showed a higher mean N-Gain, indicating a greater improvement in conceptual understanding following the AR Laboratory intervention.

The Cohen's d effect size for the posttest scores was 0.990, categorized as moderate according to the criteria used in this study. This value indicates that 83.9% of the experimental group scored above the control group's average, that 62.1% of the two distributions overlapped, and that there was a 75.8% probability that a randomly selected student from the experimental group would score higher than a randomly selected student from the control group.

Discussion

The results show that the use of the AR Laboratory application had a positive impact on students' conceptual understanding, consistent with Cai et al. (2017), who state that AR can make abstract objects more concrete through three-dimensional visualization. This finding also aligns with broader empirical evidence beyond the Indonesian context: a meta-analysis of 70 studies on interactive AR learning environments found a significant, moderate-to-large overall effect on knowledge acquisition outcomes (Hedges' g = 0.717; Yu, 2023), and systematic reviews specific to physics education report that AR most reliably improves learning when it is used, as in the present study, to visualize phenomena that are otherwise imperceptible to students, such as current flow (Vidak et al., 2023). Conceptual understanding in this study was measured based on the indicators of Anderson et al. (2001); students were considered to understand a concept if they were able to interpret, exemplify, classify, infer, compare, and explain the concept in their own words without altering its meaning.

During the learning process, students in the experimental class conducted experiments using the AR Laboratory application guided by a student worksheet (LKPD), beginning with hypothesis formulation, data collection, data analysis, and drawing conclusions from the experiments conducted. The rise in mean score from pretest to posttest in both classes reflects genuine learning gains, but several factors likely contributed to the larger gain observed in the experimental class, including students' differing prior knowledge and, most notably, the AR Laboratory application's ability to merge real and virtual environments to visualize the abstract concepts being studied — consistent with the spatial contiguity mechanism discussed in the Introduction, which reduces the cognitive load otherwise required to mentally connect the invisible flow of current with its symbolic representation in circuit diagrams.

The independent t-test on posttest scores yielded a significance value (2-tailed) of less than 0.001, which is smaller than the 0.05 significance level, so the alternative hypothesis (Ha) was accepted and the null hypothesis (H0) was rejected. This confirms that the use of the AR Laboratory application has a significant effect on students' conceptual understanding of dynamic electricity, though a significance test alone indicates only that a difference exists, not how large or educationally meaningful that difference is a question the N-Gain and effect-size analyses below address directly.

The N-Gain results showed that the mean gain for the experimental class (0.5433) fell into the moderate category, similar to the control class (0.4577), indicating that both classes experienced an improvement in conceptual understanding, although the improvement in the experimental class was relatively higher. That both classes remained within the moderate rather than the high category suggests that AR alone did not fully resolve students' difficulty with the more demanding items, such as those requiring application of current-flow reasoning rather than mere recall, and that the gain instead reflects genuine but partial conceptual restructuring, consistent with the view that a single intervention rarely eliminates deeply held difficulties with electricity concepts (Ni'mah & Widodo, 2022). This suggests that the AR Laboratory application made a positive contribution to improving students' conceptual understanding of dynamic electricity, even though the improvement obtained remained within the moderate category rather than the high category.

The Cohen's d effect size of 0.990 further indicates that the AR Laboratory media had a moderate, and practically meaningful, influence on the improvement of students' conceptual understanding. Under the four-level classification of Cohen, Manion, and Morrison (2018) used throughout this study, this value sits close to the upper boundary of the moderate category (0.51-1.00); under the more commonly used three-level convention of small/medium/large (Cohen, 1988), where $d \geq 0.80$ is considered a large effect, the same value would in fact be classified as large. In practical terms, this means that 83.9% of the experimental group scored above the control group average and that there was a 75.8% probability that a randomly selected student from the experimental group would score higher than a randomly selected student from the control group. Taken together, these findings indicate that implementing the AR Laboratory application in physics practicum activities is a promising strategy for helping students overcome the difficulty of visualizing and connecting abstract, microscopic-scale concepts in dynamic electricity with real-world phenomena.

CONCLUSION

Based on the analysis conducted, it can be concluded that the implementation of the Augmented Reality (AR) Laboratory application has a significant effect on students' conceptual understanding of dynamic electricity, as shown by an independent t-test significance value (2-tailed) of less than 0.001. Both the control and experimental classes experienced an improvement in mean score from pretest to posttest, but the improvement in the experimental class (from 16.20 to 29.12) was numerically larger than in the control class (from 8.88 to 22.92). The N-Gain analysis showed that both classes fell into the moderate category, with the experimental class (0.5433) higher than the control class (0.4577), while the Cohen's d effect size of 0.990 further confirms that the AR Laboratory application had a meaningful, moderate-to-large influence on learning outcomes. These findings indicate that the AR Laboratory application can help students overcome difficulties in visualizing and connecting abstract, microscopic-scale concepts of dynamic electricity with real-world phenomena, and can therefore be recommended as an innovative alternative learning medium for improving students' conceptual understanding of dynamic electricity. Future research could extend these findings by examining the AR Laboratory application's effect on other cognitive domains beyond conceptual understanding (C2), such as application (C3) and analysis (C4); by testing its effectiveness across a larger sample and multiple schools to improve generalizability; and by evaluating the durability of the conceptual gains observed here over a longer period following the intervention.

ACKNOWLEDGMENTS

The author would like to thank the principal, physics subject teacher, and students of SMK Negeri 2 Garut and SMK 1 Juli for their cooperation during the research process, as well as the academic supervisors at the Physics Education Study Program, Institut Pendidikan Indonesia, Garut, for their guidance throughout this study.

REFERENCES

Abraham, I., & Supriyati, Y. (2022). Desain kuasi eksperimen dalam pendidikan: Literatur review. Jurnal Ilmiah Mandala Education, 8(3), 2442-9511. https://doi.org/10.36312/jime.v8i3.3800

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Addison Wesley Longman.

Arifin, J. (2017). SPSS 24 untuk penelitian dan skripsi. PT Elex Media Komputindo.

Arikunto, S. (2009). Dasar-dasar evaluasi pendidikan (Rev. ed.). PT Bumi Aksara.

Cai, S., Chiang, F. K., Sun, Y., Lin, C., & Lee, J. J. (2017). Applications of augmented reality-based natural interactive learning in magnetic field instruction. Interactive Learning Environments, 25(6), 778-791. https://doi.org/10.1080/10494820.2016.1181094

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Erlbaum Associates.

Cohen, L., Manion, L., & Morrison, K. (2018). Research methods in education (8th ed.). Routledge.

Dewi, L. R., & Anggaryani, M. (2020). Pembuatan media pembelajaran fisika dengan augmented reality berbasis android pada materi alat optik. Jurnal Inovasi Pendidikan Fisika, 9(3), 369-376.

Endarto, I. A., & Martadi. (2022). Analisis potensi implementasi metaverse pada media edukasi interaktif. Jurnal Barik, 4(1), 37-51.

Hake, R. R. (1999). Analyzing change/gain scores. Department of Physics, Indiana University.

Hasbi, M. A. (2015). Pengembangan alat peraga listrik dinamis (APLD) berbasis inkuiri untuk meningkatkan penguasaan konsep siswa. Jurnal Penelitian Pendidikan IPA, 1(1).

Hermawan, A., & Hadi, S. (2024). Realitas pengaruh penggunaan teknologi augmented reality dalam pembelajaran terhadap pemahaman konsep siswa. Jurnal Simki Pedagogia, 7(1), 328-340.

Ibáñez, M.-B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. Computers & Education, 123, 109-123. https://doi.org/10.1016/j.compedu.2018.05.002

Khumaidi, A., & Sucahyo, I. (2018). Pengembangan mobile pocket book fisika sebagai media pembelajaran berbasis android pada materi momentum dan impuls. Jurnal Inovasi Pendidikan Fisika, 7(2), 154-158.

Mayer, R. E. (2021). Multimedia learning (3rd ed.). Cambridge University Press.

Mubarrok, M. F., & Mulyaningsih, S. (2014). Penerapan pembelajaran fisika pada materi cahaya dengan media PhET simulations untuk meningkatkan pemahaman konsep siswa di SMP. Jurnal Inovasi Pendidikan Fisika, 3(1), 76-80.

Ni'mah, M., & Widodo, W. (2022). Penerapan model pembelajaran inkuiri terstruktur berbantuan virtual-laboratory PhET untuk meningkatkan pemahaman konsep listrik dinamis. Pensa: E-Jurnal Pendidikan Sains, 10(2), 296-304.

Nugroho, W. (2023). Evaluasi usabilitas penggunaan platform metaverse dengan virtual reality menggunakan metode USE (usefulness, satisfaction, dan ease of use) [Undergraduate thesis, Universitas Atma Jaya].

Sari, A. L. R. (2018). Analisis kemampuan berpikir kritis dan pemahaman konsep siswa dalam materi hukum Newton pada model pembelajaran inkuiri terbimbing dengan multirepresentasi [Undergraduate thesis, Universitas Negeri Malang].

Siahaan, A. D., Medriati, R., & Risdianto, E. (2019). Pengembangan penuntun praktikum fisika dasar II menggunakan teknologi augmented reality pada materi rangkaian listrik dan optik geometris. Jurnal Kumparan Fisika, 2(2), 91-98. https://doi.org/10.33369/jkf.2.2.91-98

Sugiyono. (2013). Metode penelitian kuantitatif. Alfabeta.

Trihendradi, C. (2019). Step by step IBM SPSS 21 analisis data statistik. Andi Offset.

Vidak, A., Movre Šapić, I., Mešić, V., & Gomzi, V. (2023). Augmented reality technology in teaching about physics: A systematic review of opportunities and challenges. European Journal of Physics, 45(2). https://doi.org/10.1088/1361-6404/ad0e84

Yu, Z. (2023). A meta-analysis of the effects of augmented reality technologies in interactive learning environments (2012-2022). Computer Applications in Engineering Education, 31(5), 1111-1131. https://doi.org/10.1002/cae.22628