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AUGMENTED REALITY-BASED LEARNING MEDIA AS AN INNOVATIVE APPROACH TO ENHANCE STUDENTS' CONCEPTUAL COMPREHENSION AND CREATIVITY

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Abstract. Low conceptual comprehension and limited creativity remain persistent issues in Beauty and Cosmetology Education, primarily due to lecturer-centered instruction and the absence of interactive visual learning media. This study investigates the effect of Augmented Reality (AR)-based learning media on students' conceptual comprehension and creative thinking. A quasi-experimental design with a non-equivalent control group was employed involving 32 students divided into experimental and control groups. The experimental group was exposed to AR-integrated instruction, while the control group received conventional teaching. Data were collected using essay-based assessments measuring conceptual comprehension and creative thinking across the dimensions of productivity, adaptability, novelty, and elaboration. Inferential statistical analysis was applied to test mean differences between groups. Results indicate that the experimental group significantly outperformed the control group ($p < 0.05$) in both conceptual comprehension and creativity measures. These findings demonstrate that AR-based instructional media enhances cognitive processing and supports higher-order thinking through immersive visualization and contextualized learning experiences. Accordingly, AR integration offers a viable pedagogical approach for improving learning outcomes in cosmetology education, particularly in fostering conceptual mastery and creative competence.

Keywords: Augmented Reality, Conceptual comprehension, Student Creativity

Abstrak. Rendahnya pemahaman konsep dan terbatasnya kreativitas masih menjadi permasalahan yang berkelanjutan dalam pendidikan Tata Rias dan Kecantikan, terutama yang disebabkan oleh pembelajaran yang berpusat pada dosen serta minimnya media pembelajaran visual-interaktif. Penelitian ini mengeksplorasi dampak media pembelajaran berbantuan *Augmented Reality* (AR) terhadap pemahaman konsep dan kemampuan berpikir kreatif mahasiswa. Penelitian ini menerapkan metode kuasi-eksperimen dengan desain *non-equivalent control group* yang melibatkan 32 mahasiswa pada kelompok eksperimen dan kontrol. Kelompok eksperimen mengikuti pembelajaran berbantuan Augmented Reality (AR), sedangkan kelompok kontrol menggunakan pembelajaran konvensional. Data diambil melalui tes esai untuk mengukur pemahaman konsep dan kemampuan berpikir kreatif berdasarkan indikator produktivitas, adaptabilitas, kebaruan, dan elaborasi. Selanjutnya, data dianalisis menggunakan statistik inferensial untuk menguji perbedaan hasil belajar antara kedua kelompok. Hasil uji mengungkapkan mahasiswa di kelompok eksperimen mendapatkan skor lebih tinggi secara signifikan dibandingkan kelompok kontrol ($p < 0,05$). Temuan ini menunjukkan media pembelajaran berbasis AR efektif mendukung proses pembelajaran. Hasilnya mengindikasikan bahwa media pembelajaran berbasis AR mampu meningkatkan proses kognitif mahasiswa melalui visualisasi yang imersif dan pengalaman belajar yang lebih kontekstual. Dengan demikian, integrasi teknologi AR dapat menjadi alternatif strategi pembelajaran yang efektif dalam meningkatkan kualitas pembelajaran, khususnya dalam penguasaan konsep dan pengembangan kompetensi kreatif di bidang pendidikan tata rias dan kecantikan.

Kata Kunci: *Augmented Reality*, Pemahaman Konsep, Kreativitas Mahasiswa

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INTRODUCTION

The rapid advancement of Information and Communication Technologies (ICT) has transformed educational practices by creating opportunities for more innovative, interactive, and student-centered learning environments (Bacca et al., 2014). In higher education, learning is increasingly directed toward developing critical thinking, creativity, collaboration, and conceptual understanding, which are considered essential competencies for the twenty-first century (Ambarita et al., 2025; Rohmah & Russanti, 2021; Zahara et al., 2025). Consequently, the integration of technology-based instructional media has become an important strategy for improving learning effectiveness and supporting student learning outcomes.

Among emerging educational technologies, Augmented Reality (AR) has attracted considerable attention due to its ability to integrate virtual objects into real-world environments and provide immersive learning experiences (Damayanti & Nugroho, 2018). Previous studies have reported that AR can facilitate the visualization of abstract concepts, increase student engagement, improve motivation, and enhance learning achievement (Ambarita et al., 2025; Surani & Fricticarani, 2023; Zahara et al., 2025). Furthermore, AR has been found to support active learning by enabling students to explore learning materials through interactive and three-dimensional representations.

Despite these promising findings, several gaps remain in the existing literature. First, many studies primarily focus on the impact of AR on learning motivation, engagement, and academic achievement, while limited attention has been given to its role in simultaneously enhancing conceptual comprehension and creativity. Second, previous reviews often concentrate on specific disciplines or educational levels, making it difficult to obtain a comprehensive understanding of AR implementation in higher education. Third, the factors influencing the effectiveness of AR adoption, including pedagogical design, technological characteristics, and learning contexts, have not been synthesized systematically.

The novelty of this study lies in its comprehensive review of AR-assisted learning media with a specific focus on two key outcomes: conceptual comprehension and student creativity in higher education. Unlike previous studies that predominantly examine learning achievement or motivation, this study synthesizes empirical evidence regarding how AR supports deeper conceptual understanding and creative thinking skills. In addition, this review identifies the pedagogical and technological factors that influence the successful implementation of AR in higher education learning environments.

Therefore, this study aims to systematically review previous research on the use of Augmented Reality in education to examine its contribution to enhancing students' conceptual comprehension and creativity, identify factors affecting its implementation, and provide recommendations for future research and educational practice in higher education.

METHOD

This research applied a quasi-experimental non-equivalent control group design to determine the effects of AR-assisted learning media on conceptual comprehension and creativity among students. This study involved students enrolled in the Beauty and Cosmetology Education Program, divided into experimental and control groups for comparative analysis. Students in the experimental group were taught using AR-assisted learning media, while those in the control group experienced conventional learning approaches without AR integration. The sample comprised 64 students, with 32 participants in each group.

Data were collected through essay-based tests administered before and after the intervention to measure students' conceptual comprehension and creativity. The creativity instrument assessed four dimensions, namely productivity, adaptability, novelty, and elaboration. Classroom observations were also conducted to document student engagement and learning activities during the implementation process. Prior to data collection, all research instruments were validated by experts and tested for reliability to ensure their validity and consistency.

The data analysis was conducted using SPSS software. Descriptive statistics, including mean, standard deviation, minimum score, and maximum score, were first calculated to provide an overview of students' learning outcomes. Before hypothesis testing, prerequisite analyses were performed through the Shapiro-Wilk normality test and Levene's homogeneity test to determine whether the data met the assumptions for parametric analysis. To examine the effectiveness of AR-assisted learning media, an independent samples t-test was employed to compare post-test scores between the experimental and control groups. In addition, a paired samples t-test was conducted to analyze improvements in conceptual comprehension and creativity within each group from pre-test to post-test. The level of significance was set at 0.05. Furthermore, effect size analysis using Cohen's d was calculated to determine the magnitude of the impact of AR-assisted learning media on students' conceptual comprehension and creativity.

RESULTS

Data on conceptual comprehension and creative thinking were gathered from both groups through assessment activities. The data were analyzed to examine the impact of the treatment on students' performance. Data processing and statistical analysis were conducted using SPSS 21. The results were subsequently described and interpreted in the discussion section to facilitate a thorough explanation of the study findings.

Table 1. Descriptive statistics of pre-test and post-test scores

Type of data	**Pre-test**		**Post-test**	
Group	**Experimental**	**Control**	**Experimental**	**Control**
N	32	32	32	32
Mean	54.37	55.80	83.51	78.57
Min	43	44	65	62
Max	62	60	90	82
Standar Deviation	6.01	5.65	7.98	7.74

The results summarized in the table reveal a positive change in the learning outcomes of the experimental group following the intervention. Prior to the treatment, the pre-test results of the 32 participants yielded a mean score of 54.37, with scores varying between 43 and 62 and a standard deviation of 6.01. The relatively low standard deviation indicates that the data distribution within the experimental group was fairly homogeneous prior to the intervention. However, following the implementation of Augmented Reality (AR)-based instruction, the post-test results revealed a substantial increase in student performance. The improvement in mean performance indicates that AR-based instructional media played a significant role in promoting better learning outcomes among students. Overall, the results reveal that the use of AR positively influenced students' conceptual comprehension and learning outcomes, as evidenced by improvements from their pre-intervention performance.

Table 2. Results of normality, homogeneity, and independence tests from the simple t-test for pretest and posttest

Type of data		**Pre**		**Post**	
Normality	sig.	0.054	0.12	0.210	0.26
	Int.	Normal	Normal	Normal	Normal
homogen	sig.	0.751		0.893	
	Int.	homogen		homogen	
Independent of simple t-test	sig.	0.01		0.012	
	Int.	significant		significant	

The normality analysis demonstrated that the significance values for all pre-test and post-test scores in both groups were above 0.05, suggesting that the data followed a normal distribution. Similarly, the homogeneity analysis yielded significance values greater than 0.05, confirming that the variances among the groups were statistically homogeneous. Furthermore,

the Independent Samples t-test yielded significance values of 0.010 for the pre-test and 0.012 for the post-test. Since both p-values were below 0.05, significant differences were observed between the experimental and control groups in both assessments. The normality analysis indicated that all pre-test and post-test data had significance values greater than 0.05, confirming that the data in both groups were normally distributed.

The analysis of variance homogeneity revealed significance values greater than 0.05 for both assessments, indicating that the data exhibited homogeneous variances between the groups. Analysis of the Independent Samples t-test indicated significant values of 0.010 and 0.012 for the pre-test and post-test, respectively. These results provide evidence of statistically significant differences between the experimental and control groups throughout the study.

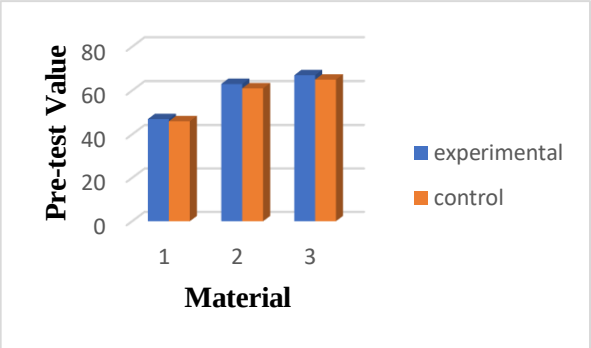

Figure 1. Comparison of mean pre-test scores for each learning topic

The pre-test graph shows that both groups displayed similar achievement levels in design elements, design principles, and color in beauty design prior to the intervention. This finding indicates that the students' initial abilities in both groups were generally homogeneous prior to the implementation of the instructional intervention. Furthermore, the pre-test results reveal a progressive increase in students' initial understanding from design elements to design principles and subsequently to color in beauty design. The topic of color achieved the highest mean score, followed by design principles, while design elements recorded the lowest performance. This suggests that more practical and visually oriented concepts, such as color, tend to be easier for students to comprehend than fundamental design concepts. These findings provide valuable insights for the development of more effective instructional strategies, particularly for teaching design elements.

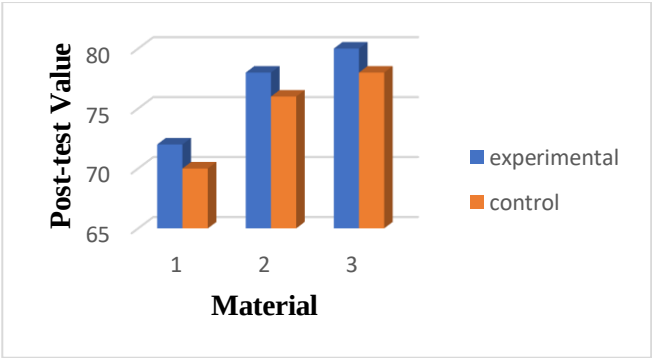

Figure 2. Mean Post-Test Scores Across Different Learning Topics

Based on the post-test score distribution, the experimental group exhibited consistently higher achievement levels than the control group across the topics of design elements, design principles, and color in beauty design. This finding suggests that the intervention was effective in facilitating deeper conceptual understanding and improved learning outcomes among students. Furthermore, the post-test results demonstrated improvements in students' comprehension of the three topics, namely design elements, design principles, and color in beauty design. The topic of color attained the highest level of achievement, followed by design principles, while design elements, although showing improvement, remained a foundational topic requiring further instructional reinforcement. The observed differences in scores between the two groups imply that the instructional intervention administered to the experimental group contributed more substantially to the development of students' understanding of beauty design concepts.

Table 3. Statistical Analysis Results of Students' Creative Thinking Skills

Type of data	**Tes keterampilan berpikir kreatif**	
Group	**Experimental**	**control**
N	32	32
Mean	17.56	16.21
Min	15	15
Max	23	20
Standar Deviation	3.15	2.28

Based on the data presented in the table above, the assessment of students' creative thinking skills was conducted for both the experimental and control groups. The results indicate that the experimental group exhibited a relatively wider variation in scores among students; however, the distribution remained within an acceptable range. Compared with the control group, which exhibited a more homogeneous score distribution, the experimental group achieved significantly stronger creative thinking outcomes. Although the experimental group showed a marginally higher degree of score variability, its overall level of creative thinking

performance remained substantially higher, indicating the effectiveness of the implemented instructional approach. These findings imply that the instructional intervention implemented in the experimental group may have contributed positively to the enhancement of students' creative thinking skills.

Table 4. Results of normality, homogeneity, and independence tests from the simple t-test for the experimental and control groups

Type of data		Experimental	control
Normalitas test	sig.	0.12	0.070
	Int.	Normal	Normal
homogen test	sig.	0.062	
	Int.	homogen	
Independent of simple t-test	sig.	0.031	
	Int.	significant	

Based on the statistical findings, all normality test significance values exceeded 0.05 ($p > 0.05$), indicating that the data from both groups followed a normal distribution. Moreover, the homogeneity test confirmed equal variances between the experimental and control groups, suggesting that the dataset fulfilled the prerequisites for parametric analysis. The Independent Samples t-test indicated a statistically significant difference in creative thinking skills between the experimental and control groups, as evidenced by a p-value below 0.05. The assumption tests confirmed that the data were normally distributed and exhibited homogeneous variances, validating the suitability of the Independent Samples t-test for further analysis. The significant group differences observed indicate that the instructional treatment implemented in the experimental group was effective in fostering higher levels of creative thinking among students.

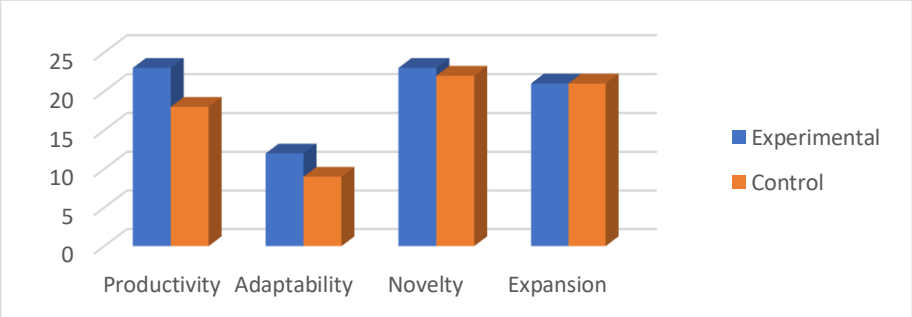

Figure 3. The graph of students' creative thinking skills test results

Based on Figure 3, the experimental group generally achieved slightly higher scores than the control group across several creativity indicators, namely productivity, adaptability, novelty, and expansion. However, the differences between the two groups were relatively small, suggesting that the improvement in creativity was moderate and not substantially

significant in practical terms. The consistently elevated scores attained by the experimental group provide evidence that the instructional treatment may have facilitated improvements in several aspects of students' creative thinking skills.

The experimental group demonstrated higher performance in the productivity dimension compared with the control group; however, the difference between the groups was relatively limited. Similarly, in the adaptability dimension, the experimental group demonstrated slightly better performance, indicating an improvement in students' ability to adjust their ideas and approaches to new situations, albeit to a limited extent. For the novelty dimension, both groups obtained relatively similar results, with the experimental group showing a marginal advantage. This finding suggests that students' ability to generate new and innovative ideas improved following the instructional intervention. Collectively, these findings highlight the effectiveness of the learning approach in strengthening students' creative thinking capabilities, as reflected in enhanced productivity, adaptive thinking, and originality across various creative tasks.

In contrast, the scores for the expansion dimension were nearly identical between the experimental and control groups. This finding indicates that students' ability to elaborate on and expand ideas remained relatively similar across both groups. Therefore, the results suggest that the instructional approach implemented in the experimental group tended to promote improvements in creative thinking skills, particularly in the areas of productivity, adaptability, and idea novelty. However, given that the differences between the two groups were relatively small, the improvement in students' creativity can be considered present but not substantially significant. Consequently, more intensive and sustained instructional strategies may be required to optimize the development of students' creativity across all dimensions of creative thinking.

DISCUSSION

The Concept and Characteristics of *Augmented Reality* (AR) in Education

The advancement of digital technologies has driven the emergence of innovative instructional media designed to enhance the effectiveness of teaching and learning processes, including Augmented Reality (AR) as a key examp. AR technology merges digital elements with the physical environment, allowing users to interact with virtual content in an engaging and immersive manner. Within educational contexts, AR has the potential to make abstract concepts more comprehensible by presenting them through 3D visualization, animation, and interactive simulation, thereby improving conceptual understanding (Buwono et al., 2025; Herawati et al., 2023; Larasati & Widyasari, 2021; Nur et al., 2024). These capabilities can

help students comprehend learning materials more comprehensively and strengthen their conceptual comprehension through visual and application-oriented learning experiences. Furthermore, AR promotes a dynamic learning environment that encourages students to explore ideas, solve problems, and develop creativity more actively (Herawati et al., 2023; Rais et al., 2024).

However, the application of AR in education is associated with several challenges, including access to adequate technological infrastructure, stable internet access, and users' digital readiness. These limitations may affect the effectiveness of AR-based learning if they are not supported by appropriate technological infrastructure and well-designed instructional strategies(Ambarita et al., 2025). Therefore, the successful implementation of AR is determined not only by the sophistication of the technology itself but also by the effectiveness of instructional strategies, the readiness of educators, and students' ability to adapt to digital-based learning environments(Yandra & Oktarina, 2026; Zahara et al., 2025). When implemented effectively, AR has considerable potential to enhance students' conceptual comprehension and creativity within higher education learning environments.

The Role of AR in Improving Students' Conceptual comprehension

AR-assisted learning media integration has been found to improve students' conceptual comprehension by providing more meaningful and engaging learning experiences. (Rais et al., 2024; Rohmah & Russanti, 2021) AR technology enhances learning by providing immersive three-dimensional visualizations and interactive simulations that transform abstract concepts into more concrete representations, thereby improving students' comprehension of complex subject matter (Bacca et al., 2014; Lusiana et al., 2025; Surani & Fricticarani, 2023). In conventional learning environments, instructional content is often delivered through lecture-based methods and the use of static media, which may hinder students' ability to fully comprehend certain concepts. AR serves as an interactive instructional medium that enables students to observe visualized objects and actively interact with learning materials, promoting deeper comprehension of the content being studied (Buwono et al., 2025; Komala et al., 2021; Sari et al., 2025). This condition makes the learning process more enjoyable while facilitating students' mastery of the learning material.

Empirical evidence indicates that AR enhances student engagement in educational settings by providing interactive learning experiences that involve observation, exploration, and simulation-based activities (Lin et al., 2024). Such an active learning environment contributes to improved conceptual comprehension, as students actively participate in knowledge

construction rather than merely receiving information passively. The integration of gamification-based AR has been shown to increase students' engagement and motivation throughout the learning process (Jogo & Rosmayana, 2025). Despite the lack of statistically significant improvements in learning achievement, AR contributed positively to students' learning experiences and conceptual understanding. The findings further suggest that the impact of AR is moderated by implementation duration, learners' readiness to use the technology, and the quality of instructional design.

Furthermore, previous research indicates that the utilization of AR as a learning medium is effective in enhancing reading comprehension and facilitating the process of meaning-making in information processing (Tuli & Mantri, 2021). These findings confirm that AR has the capability to improve the quality of learning through visual and interactive approaches. In addition, previous studies highlight that the ability of AR to visualize abstract concepts constitutes a major factor contributing to the enhancement of students' understanding. Learning content that is difficult to grasp through text-based explanations or two-dimensional representations can be made more concrete through simulations and virtual objects (Aryani et al., 2024; Huda et al., 2021). Thus, students gain a deeper and more contextualized learning experience.

The Role of Augmented Reality in Fostering Students' Creative Thinking Skills

Apart from its positive effects on conceptual understanding, the use of AR-assisted learning media has been shown to facilitate the development of students' creativity. Creativity represents an essential competency in modern education, reflecting an individual's capacity to generate original ideas, formulate solutions, and think innovatively (Nincarean et al., 2013; Purwanti et al., 2022). In higher education settings, the development of creativity is essential for preparing students to respond effectively to technological advancements and workplace challenges (Morkovkin et al., 2020). The use of AR in learning enables students to gain more exploratory and interactive learning experiences. Through visualization in virtual objects, digital simulations, and interaction-based activities, students are encouraged to independently explore learning materials. Such conditions foster a more active learning atmosphere in which students engage directly in the process of acquiring and constructing knowledge rather than simply receiving information (Kisno & Fatmawati, 2023).

Based on the analyzed research findings, the use of AR is capable of enhancing students' creativity through experiential learning approaches. Students are given opportunities to explore learning materials through visual and simulation-based approaches that stimulate imagination

and creative thinking skills. In addition, AR encourages students to become more active in problem-solving and in developing new ideas throughout the learning process. The implementation of AR-supported Group Investigation learning has been shown to exert a significant positive influence on students' creative thinking and creativity development. The use of active learning models combined with AR technology enables students to work collaboratively, engage in discussions, and explore learning materials in greater depth. (Mustaqim, 2016). This finding suggests that the effectiveness of AR in fostering creativity is determined not only by the technology used, but also by the instructional strategies implemented.

Determinants of Augmented Reality Adoption in Learning Environments: Enabling and Constraining Factors

The successful implementation of Augmented Reality (AR) in educational settings is influenced by the interaction of technological, pedagogical, and human factors. One of the primary strengths of AR lies in its capacity to create immersive and interactive learning experiences through the integration of three-dimensional visualizations and digital simulations. Such features enable learners to engage with abstract concepts more concretely, thereby increasing learning engagement, motivation, and opportunities for self-directed exploration. Previous studies have shown that AR becomes more effective when integrated with active learning approaches, such as collaborative learning, group discussions, and project-based learning, because these strategies encourage students to actively construct knowledge while simultaneously developing creativity and critical thinking skills.

Beyond pedagogical considerations, technological infrastructure plays a critical role in determining the effectiveness of AR adoption. The availability of compatible devices, stable internet connectivity, and accessible AR applications facilitates smoother implementation and enhances the overall learning experience. However, the findings also indicate that technological readiness alone is insufficient to guarantee successful AR integration. The effectiveness of AR is strongly dependent on educators' ability to design meaningful learning experiences and to align technological features with instructional objectives. This finding suggests that AR should be viewed not merely as a technological innovation but as a pedagogical tool whose educational value depends on how it is integrated into the learning process.

Despite its potential benefits, several constraints continue to limit the adoption of AR in educational environments. Technical challenges, including device limitations, unstable internet connections, and software performance issues, frequently reduce the effectiveness of AR-based learning. Furthermore, insufficient digital literacy among both educators and students may hinder the optimal utilization of AR applications. These findings are consistent with previous studies that identified technological readiness as a major determinant of successful AR implementation (Bacca et al., 2015; Gargrish et al., 2020; Guo et al., 2020). More importantly, the findings reveal that the transition from teacher-centered instruction to technology-supported student-centered learning often requires substantial pedagogical adaptation, which may create resistance or implementation difficulties in practice.

Another important issue emerging from the literature is the risk of cognitive overload. While AR enriches learning through multimodal representations, excessive visual stimuli or poorly designed interfaces may overwhelm learners' cognitive processing capacity. As a result, students may focus more on interacting with technological features than on understanding the learning content itself. This finding highlights that the educational effectiveness of AR is not solely determined by the sophistication of the technology but also by the quality of instructional design. Therefore, AR-based learning environments should be designed to balance technological interactivity with cognitive demands to ensure meaningful learning outcomes.

Overall, the reviewed studies suggest that AR has considerable potential to enhance conceptual understanding, creativity, and learning engagement. Nevertheless, its effectiveness remains context-dependent and is influenced by infrastructure availability, user readiness, instructional design quality, and educators' technological competence. These findings imply that future educational initiatives should focus not only on expanding access to AR technologies but also on strengthening pedagogical strategies and digital competencies to maximize the educational benefits of AR implementation.

CONCLUSION

The findings demonstrate that the implementation of AR-assisted instructional media contributes positively to the enhancement of students' conceptual comprehension and creative thinking by enabling collaborative interactions, immersive visualizations, and contextually grounded learning experiences. The implementation of AR can optimize student engagement through exploration, discussion, and problem-solving activities, thereby supporting the development of creativity and critical thinking skills. However, the application of AR still faces several challenges, such as limitations in technological infrastructure, digital literacy, and the

potential for cognitive overload when not supported by appropriate instructional design. Accordingly, the success of AR integration is shaped by a combination of factors, including infrastructure preparedness, instructional design, and educators' professional competencies, rather than by technological capabilities alone. Future research should examine the implementation of AR in combination with different pedagogical approaches using broader empirical frameworks to better understand its potential for improving learning outcomes in the digital age.

RECOMMENDATIONS

The findings suggest that AR-assisted learning media can serve as an effective and innovative instructional strategy for enhancing conceptual comprehension and creativity among students in Beauty and Cosmetology Education. Lecturers are encouraged to incorporate AR tools into teaching practices to provide more interactive, visual, and contextual learning experiences that support higher-order thinking skills. Institutions should also prioritize the development and provision of AR-based learning resources, including relevant digital content and infrastructure, to ensure effective implementation in classroom settings. Furthermore, training programs and workshops should be conducted to improve lecturers' digital competencies in designing and applying AR-based instructional media. Regular evaluation of AR-based learning initiatives is necessary to investigate their long-term influence on educational outcomes and to inform the continuous improvement of instructional strategies. Further research should investigate the application of AR across broader participant populations and different subject domains, while also examining its integration with emerging technologies, including artificial intelligence (AI) and virtual reality (VR), to optimize learning outcomes.

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