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Augmented reality-supported artistic anatomy instruction and studio-based figure drawing performance: a quasi-experimental embedded mixed-methods study

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ABSTRACT

This study examined the effects of augmented reality (AR)-supported artistic anatomy learning on fine arts students' figure drawing performance in higher education and explored students' perceptions of the usability, engagement, and pedagogical value of AR in studio-based anatomy learning. A quasi-experimental embedded mixed-methods design was employed with an experimental group receiving AR-supported artistic anatomy instruction and a control group receiving conventional instruction. Participants were 63 undergraduate fine arts students (31 experimental; 32 control). Data were collected through pre-test and post-test figure drawing tasks, a student perception questionnaire, and qualitative discussions with selected students and lecturers. Students' drawings were assessed using a rubric covering proportion, perspective, anatomical structure, gesture, and spatial coherence. The AR-supported group showed greater improvement than the conventional group, with the largest descriptive post-test differences in perspective and spatial coherence. Students also reported high usability, engagement, and pedagogical value. Qualitative findings indicated that rotation, scaling, and multi-angle exploration helped students examine three-dimensional bodily form before translating it into two-dimensional drawings. These findings extend AR-supported anatomy research into fine arts studio pedagogy and indicate that AR can function as a complementary visual-spatial learning tool when its affordances are aligned with discipline-specific drawing tasks.

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Introduction

Artistic anatomy is a foundational component of fine arts higher education because students must do more than identify anatomical structures: they must understand how skeletal and muscular forms generate visible proportion, gesture, volume, perspective, and spatial relationships in figure drawing. This learning task is inherently visual-spatial and practice-based, requiring students to translate three-dimensional bodily structures into coherent two-dimensional representations. Recent higher-education reviews and spatial-learning research indicate that augmented reality (AR) can be especially relevant when learners must inspect, manipulate, and interpret three-dimensional forms from changing viewpoints (Li et al., 2025; Yang et al., 2025).

Despite its importance, artistic anatomy remains pedagogically demanding. Students may recognize anatomical forms in static references but still struggle to represent the body from unfamiliar viewpoints, including high-angle, low-angle, and foreshortened poses. Studies in technical and engineering drawing similarly report persistent difficulties in spatial visualization and show that AR can support perspective-related learning when students are required to mentally manipulate three-dimensional forms (Akkus & Arslan, 2022; Baltaci & Çetin, 2022). Although this evidence originates in engineering and technical-drawing contexts rather than fine arts, the underlying visual-spatial demand—mentally reconstructing and manipulating three-dimensional form from a fixed viewpoint—is shared across disciplines even though the pedagogical goal differs (technical precision versus expressive figurative representation); this shared cognitive demand, rather than disciplinary similarity, is the basis for extending AR research into artistic anatomy. Conventional resources such as textbooks, slides, two-dimensional illustrations, and static models remain useful, but they do not always allow students to rotate, enlarge, and inspect bodily structures dynamically.

AR provides a potentially relevant response because it overlays interactive digital objects within the learner's visual environment and enables rotation, scaling, close inspection, and multi-angle exploration (Álvarez-Marín & Velázquez-Iturbide, 2021). Broader work on AR/VR learning similarly highlights the importance of interactive visualization, usability, and learner–technology interaction rather than technological novelty alone (Cevikbas et al., 2023; Ghobadi et al., 2023; Samala et al., 2023). Within artistic anatomy, these affordances may help students examine how three-dimensional structure changes under viewpoint and then apply that observation to drawing. Recent studies published in the Journal of Educational Studies also indicate that AR and interactive visual media can support learning when visualizing complex or abstract content, although the reported contexts have primarily involved school-level science and problem solving rather than fine arts studio practice (Sakti & Abdurrahman, 2026; Wati et al., 2026).

Most AR-supported anatomy research has been conducted in medical, health-science, and science education. Systematic reviews, meta-analyses, and recent three-dimensional anatomy studies generally report benefits for anatomical visualization and spatial interpretation, while also emphasizing that learning effects depend on instructional design and implementation conditions (Bölek et al., 2021; Fahrni & Sabatasso, 2025; García-Robles et al., 2024; Minouei et al., 2024; Salimi et al., 2024). In arts education, immersive technologies have been examined as tools for visual exploration and creative learning, but the literature remains much thinner than in health education and often focuses on technology use rather than discipline-specific performance outcomes (González-Zamar & Abad-Segura, 2020; Hui et al., 2022; Mao & Ling, 2025). In artistic anatomy, students must transform anatomical understanding into visual production, including proportion, perspective, gesture, and spatial coherence. This distinction limits direct transfer from medical anatomy findings and creates a discipline-specific research gap. The present study addresses this gap directly by comparing AR-supported instruction against a conventional, non-AR condition that covers identical content, learning objectives, and assignments, thereby providing an explicit baseline against which the contribution of AR can be evaluated. To the authors' knowledge, this is among the first studies to test AR-supported instruction within studio-based fine arts pedagogy rather than medical, engineering, or general science contexts, extending prior AR-spatial learning evidence (e.g., Li et al., 2025; Yang et al., 2025) to a discipline with distinct expressive and representational goals.

The present study is therefore grounded primarily in Task-Technology Fit theory. Task-Technology Fit proposes that technology is most likely to improve performance when its capabilities correspond to the requirements of the task (Goodhue & Thompson, 1995). In artistic anatomy learning, rotation, scaling, and multi-angle visualization are relevant because the studio task requires students to analyze bodily form from changing viewpoints and translate that form into drawings. This interpretation is consistent with research integrating task-technology fit with educational technology adoption, which emphasizes that perceived usefulness alone is insufficient when technological features do not match learning demands (Faqih & Jaradat, 2021; Alturki & Aldraiweesh, 2023).

Cognitive Theory of Multimedia Learning provides a complementary explanation for how visual and verbal representations can be coordinated during learning (Mayer, 2021). This is also consistent with work on interactive mobile learning content, which emphasizes that visual interactivity must be organized around instructional goals rather than added as decoration (Al-Amri et al., 2023). Experiential learning further emphasizes learning through experience, reflection, conceptualization, and application (Kolb, 2015), while studio pedagogy relies on cycles of observation, practice, feedback, comparison, and revision that resemble reflective professional learning (Schön, 1983). In this study, AR is therefore treated not as a stand-alone digital novelty but as a pedagogical support embedded within studio practice. Students use AR to inspect body structure, compare visual relationships, make drawing decisions, and revise their work.

Accordingly, this study examines whether AR-supported artistic anatomy learning improves discipline-specific figure drawing performance and how students experience AR within studio-based learning. Visual-spatial improvement is operationalized through the drawing rubric rather than through a separate standardized spatial ability test, particularly through the dimensions of perspective and spatial coherence. The study addresses four research questions: (1) To what extent does AR-supported artistic anatomy learning improve fine arts students' figure drawing performance? (2) Which aspects of figure drawing performance show the greatest improvement, particularly proportion, perspective, anatomical structure, gesture, and spatial coherence? (3) How do students perceive the usability, engagement, and pedagogical value of AR in studio-based artistic anatomy learning? and (4) How do students and lecturers explain the role of AR in supporting anatomical observation and figure drawing practice?

Methods

Research Design and Participants

This study employed a quasi-experimental embedded mixed-methods design with a pre-test–post-test non-equivalent control group. The quantitative component was used to compare learning outcomes before and after the intervention, while the qualitative component was embedded to explain students' and lecturers' experiences of AR-supported studio learning. The design was selected because the study was conducted in intact classroom settings in which individual random assignment was not feasible (Cohen et al., 2018; Creswell & Plano Clark, 2018). Because randomization at the individual level was not possible, baseline comparability between the two intact classes was examined descriptively using pre-test scores (see Section 3.1); the two groups showed similar pre-test means, offering preliminary support for comparable starting performance, although a formal statistical equivalence test was not conducted and is noted as a limitation. The sample size (N = 63) was determined by the number of students enrolled in the two available intact classes rather than through an a priori power analysis, a pragmatic constraint common in classroom-based quasi-experimental research.

The participants were 63 undergraduate students enrolled in an Artistic Anatomy course in the Department of Fine Arts, Universitas Negeri Padang. Two intact classes participated: 31 students formed the AR-supported experimental group and 32 students formed the conventional-learning control group. Both groups studied the same topics, including human body proportion, body perspective, visual anatomical structure, gesture, and the application of anatomy in figure drawing. To reduce instructor-related variation, both groups were taught by the same lecturer using equivalent learning objectives, instructional time, and drawing assignments; the principal instructional difference was the use of AR for anatomical exploration in the experimental group.

Intervention

The intervention was implemented in one approximately 150-minute session per week. Both groups received the same learning objectives, content, and figure drawing assignments. The experimental group used AR media to explore three-dimensional human-body models before and during drawing activities. Students could rotate anatomical models, enlarge visual details, and examine bodily structures from multiple viewpoints. AR exploration was structured rather than open-ended: in each session, the lecturer assigned a short list of targeted viewing tasks aligned with that week's topic (e.g., rotating the model to a specified low or high angle and identifying the resulting foreshortening) before students proceeded to independent drawing, so that AR use was directly tied to the drawing exercise rather than left to unguided browsing. These activities were intended to support observation of proportion, perspective, anatomical structure, gesture, and spatial relationships before students translated those observations into figure drawings.

The control group learned the same artistic anatomy topics through conventional resources, including textbooks, two-dimensional images, presentation slides, and lecturer demonstrations. AR did not replace drawing practice, critique, or lecturer guidance in the experimental group; it functioned as an additional visual-spatial reference integrated into the studio task.

Data Collection

Instrument of Collecting Data

Four instruments were used. First, pre-test and post-test figure drawing tasks measured students' figure drawing performance before and after the intervention. The tasks required students to draw a human figure from specified poses or viewpoints with equivalent levels of difficulty.

Second, a figure drawing assessment rubric was used to evaluate the drawings systematically. The rubric contained five dimensions: proportion, perspective, anatomical structure, gesture, and spatial coherence. Each dimension was rated from 1 to 5, producing a maximum total score of 25. The use of explicit rubric dimensions was intended to support consistent evaluation of complex studio products (Panadero et al., 2023). Raters were trained together using shared exemplars and a common scoring guide to support consistent application of the rubric; however, a formal inter-rater reliability coefficient (e.g., Cohen's kappa or intraclass correlation) was not calculated in this study, and its absence is acknowledged as a limitation in the Discussion.

Third, a student perception questionnaire was administered to the AR-supported group after the intervention to examine usability, engagement, and pedagogical value. Fourth, qualitative discussions with selected students and lecturers were used to explore how AR was experienced during learning, including perceived benefits, technical challenges, anatomical observation, and its relevance to drawing practice. Students for the qualitative discussions were purposively selected from the AR-supported group to capture a range of experiences with the AR media, together with the course lecturer; discussions followed a semi-structured guide addressing usability, engagement, technical challenges, and perceived links between AR use and drawing decisions. Internal consistency (Cronbach's alpha) for the perception questionnaire was not computed in the present analysis and should be reported in future replications.

Techniques for Collecting Data

Both groups completed the pre-test before instruction and the post-test after the intervention. Figure drawings were scored using the same five-dimension rubric. Students in the experimental group then completed the perception questionnaire. Qualitative data were collected after the intervention from selected students and lecturers to clarify how AR features were used during studio tasks and to explain patterns observed in the quantitative findings.

The qualitative component was used to explain how students and lecturers experienced AR during studio-based artistic anatomy learning and to clarify how the visual features of AR were connected to observation, comparison, and drawing practice.

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Paired-sample t-tests examined within-group differences between pre-test and post-test figure drawing scores. An independent-samples t-test compared gain scores between the AR-supported and conventional groups. ANCOVA compared post-test scores between groups while controlling for pre-test scores, and effect sizes were reported to indicate the magnitude of differences.

Questionnaire data were summarized descriptively using means and standard deviations for usability, engagement, pedagogical value, and overall perception. Qualitative data were analyzed through thematic coding. The qualitative findings were used as explanatory evidence to clarify how students used AR features, how lecturers observed student behavior, and how visual-spatial strategies during drawing practice may have contributed to the quantitative pattern. This integration is consistent with an embedded mixed-methods logic in which qualitative evidence explains or elaborates quantitative results (Creswell & Plano Clark, 2018).

Results and Discussion

Result

The results are presented in three parts: overall figure drawing performance, rubric-level performance and student perceptions, and qualitative explanations of students' and lecturers' experiences. Figure drawing performance was assessed on five dimensions—proportion, perspective, anatomical structure, gesture, and spatial coherence—each rated from 1 to 5 for a maximum total score of 25.

Overall Figure Drawing Performance

Descriptive statistics indicated relatively comparable initial performance. The AR-supported group obtained a pre-test mean of 14.37 (SD = 1.86), while the conventional group obtained a pre-test mean of 14.66 (SD = 2.06). After the intervention, the AR-supported group increased to 19.52 (SD = 2.22), whereas the conventional group increased to 17.45 (SD = 2.24).

Table 1. Descriptive Statistics of Figure Drawing Performance

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Gain Mean	Gain SD
AR-supported learning	31	14.37	1.86	19.52	2.22	5.15	1.28
Conventional learning	32	14.66	2.06	17.45	2.24	2.78	1.22

Both groups improved from pre-test to post-test, but the AR-supported group showed a larger mean gain (M = 5.15, SD = 1.28) than the conventional group (M = 2.78, SD = 1.22). Paired-sample t-tests showed significant improvement in the AR-supported group, $t(30) = 22.37$, $p < .001$, Cohen's $d_z = 4.02$, and in the conventional group, $t(31) = 12.94$, $p < .001$, Cohen's $d_z = 2.29$. An independent-samples t-test showed that gain scores were significantly higher for the AR-supported group, $t(61) = 7.52$, $p < .001$, Cohen's $d = 1.89$. ANCOVA further indicated a significant group effect on post-test performance after controlling for pre-test scores, $F(1, 60) = 54.93$,

$p < .001$, partial $\eta^2 = .48$. Assumption checks for the ANCOVA (normality of residuals, homogeneity of variance, homogeneity of regression slopes) were not formally tested in this analysis and should be verified in future replications with larger samples.

Table 2. Summary of Inferential Analyses for Figure Drawing Performance

Analysis	Comparison	Test statistic	p	Effect size
Paired-sample t-test	AR-supported pre-test vs post-test	t(30) = 22.37	< .001	Cohen's dz = 4.02
Paired-sample t-test	Conventional pre-test vs post-test	t(31) = 12.94	< .001	Cohen's dz = 2.29
Independent-samples t-test	Gain: AR-supported vs conventional	t(61) = 7.52	< .001	Cohen's d = 1.89
ANCOVA	Post-test by group, controlling for pre-test	F(1,60) = 54.93	< .001	partial η^2 = .48

Rubric Dimensions and Student Perceptions

Rubric-based analysis showed that the AR-supported group obtained higher post-test means across all five figure drawing dimensions. The largest group differences were observed in perspective and spatial coherence, two dimensions that most directly reflect visual-spatial organization within figure drawing. As shown in Table 3, the size of the AR-related advantage varied across dimensions, with proportion and anatomical structure showing comparatively smaller differences than perspective and spatial coherence, indicating that the benefit of AR was not uniform across all rubric dimensions.

Table 3. Post-test Scores by Figure Drawing Rubric Dimension

Aspect	AR-supported Mean	AR-supported SD	Conventional Mean	Conventional SD
Proportion	4.04	0.61	3.48	0.66
Perspective	4.12	0.58	3.31	0.71
Anatomical structure	3.89	0.64	3.44	0.63
Gesture	3.94	0.67	3.53	0.69
Spatial coherence	4.17	0.55	3.52	0.68

The student perception questionnaire was administered to the AR-supported group after the intervention. Engagement received the highest mean score (M = 4.34, SD = 0.46), followed by pedagogical value (M = 4.28, SD = 0.51) and usability (M = 4.21, SD = 0.49). The overall perception score was M = 4.27 (SD = 0.48).

Table 4. Student Perceptions of AR-Supported Learning

Dimension	Mean	SD
Usability	4.21	0.49
Engagement	4.34	0.46
Pedagogical value	4.28	0.51
Overall perception	4.27	0.48

Qualitative Findings and Mixed-Methods Integration

The qualitative analysis produced three main themes: AR as a visual exploration tool, AR as a support for connecting anatomy with drawing practice, and technical challenges in AR use.

First, students experienced AR as more flexible than static visual references. Three-dimensional models allowed them to examine the body from above, below, the side, and oblique angles and to interpret the figure as a form with volume, depth, and direction. Rotation and multi-angle viewing were particularly useful when students examined how bodily forms changed across viewpoints.

Second, students used AR to connect anatomical observation with drawing decisions. They compared their drawings with the AR model and identified issues involving proportion, foreshortening, perspective, and spatial organization. Lecturer observations similarly indicated that students in the AR-supported group were more active in examining body structure, asking viewpoint-related questions, and revising drawings based on self-directed visual exploration.

Third, some students experienced initial technical difficulties, including marker scanning, camera positioning, and model stability. These difficulties were more noticeable on lower-specification devices or under poor lighting, but they tended to decrease as students became familiar with the AR media.

Integration of the quantitative and qualitative findings produced a coherent pattern. The largest quantitative differences occurred in perspective and spatial coherence, while the qualitative findings described repeated use of rotation, scaling, and multi-angle exploration to inspect depth, viewpoint, and three-dimensional form. The perception data also indicated that students regarded AR as usable, engaging, and pedagogically relevant. Together, the findings suggest that AR contributed not only through increased engagement but also by providing visual-spatial support closely aligned with the demands of figure drawing.

The findings indicate that students receiving AR-supported artistic anatomy instruction improved more than those receiving conventional instruction. The AR-supported group achieved a mean gain of 5.15 compared with 2.78 in the conventional group, and the between-group gain difference was large (Cohen's d = 1.89). Within the limits of the quasi-experimental design, this pattern suggests that integrating AR into artistic anatomy instruction can provide measurable performance benefits when the technology is tied directly to studio tasks rather than used only for demonstration.

The strongest post-test differences appeared in perspective and spatial coherence. These dimensions require students to maintain viewpoint consistency, represent depth, and organize bodily forms as coherent three-dimensional structures within two-dimensional drawings. The result is consistent with AR research in technical drawing and spatial learning, where interactive manipulation of three-dimensional models has been associated with improved spatial visualization and perspective-related performance (Akkus & Arslan, 2022; Baltaci & Çetin, 2022; Yang et al., 2025). It also extends findings from anatomy education, where AR has been used primarily to support structural identification and spatial relationships rather than artistic production (Bölek et al., 2021; García-Robles et al., 2024; Salimi et al., 2024).

Task-Technology Fit provides a useful explanation for the pattern. AR was not beneficial merely because it was digital; its affordances matched specific demands of artistic anatomy. Rotation supported inspection from changing viewpoints, scaling supported examination of detail and proportion, and multi-angle visualization supported comparison of perspective and spatial relationships. These features corresponded directly to drawing decisions students had to make. The finding therefore supports the central TTF proposition that performance benefits depend on alignment between technological capabilities and task requirements (Goodhue & Thompson, 1995; Faqih & Jaradat, 2021).

The findings can also be interpreted through multimedia and experiential learning perspectives. Multimedia learning emphasizes purposeful coordination of visual representations with explanatory information (Mayer, 2021), while experiential learning emphasizes cycles of experience, reflection, conceptualization, and application (Kolb, 2015). In studio practice, students repeatedly observe, draw, compare, receive feedback, and revise. AR enriched the observation and comparison phases by giving students manipulable three-dimensional references, but the learning benefit still depended on drawing practice and revision. This is consistent with reflective studio learning, in which professional understanding develops through action and reflection rather than through passive exposure to information alone (Schön, 1983).

The results also contribute to the growing educational technology literature in the Journal of Educational Studies. Wati et al. (2026) reported improved problem-solving and cognitive outcomes in an AR-supported elementary-school context, while Sakti and Abdurrahman (2026) reported increased learning interest with interactive multimedia. Both of these studies were published in an Indonesia-based journal, which helps ground the present findings within the regional educational technology literature in addition to the predominantly international AR and anatomy education sources cited elsewhere in this paper. Related higher-education research has also linked AR-integrated learning with student engagement and broader learning outcomes, although in different disciplinary and instructional settings (Yusuf, 2025). The present study differs in level, discipline, and outcome: it examines higher-education fine arts and evaluates a performance product using discipline-specific drawing criteria. Its contribution is therefore not simply another positive response to AR, but evidence that AR affordances can be connected to practice-based artistic performance.

Student perceptions were positive, with engagement receiving the highest mean. However, positive perception should not be interpreted as evidence of learning effectiveness on its own. In this study, the perception results are most useful as explanatory evidence because they align with observed behavior and measured performance. Students described AR as useful for examining body form and making revisions, while the quantitative gains were strongest in the dimensions most closely related to visual-spatial exploration. This convergence strengthens the interpretation that the instructional value of AR came from task-relevant visual interaction rather than novelty alone.

A remaining question is whether the AR group's advantage reflects novelty rather than pedagogical value, since no formal measure of treatment fidelity or instructor equivalence beyond curriculum content was collected. Two aspects of the data speak against a purely novelty-driven account. First, the qualitative theme of technical difficulty (marker scanning, camera positioning) decreased as students became familiar with the AR media, which is the opposite pattern expected if gains were driven mainly by initial excitement with a new tool. Second, both groups were taught by the same lecturer using equivalent objectives and time, and the AR group's advantage was concentrated in the dimensions (perspective, spatial coherence) most directly tied to AR's visual-spatial affordances rather than distributed evenly across all rubric dimensions, which is more consistent with a task-relevant mechanism than with generalized engagement or instructor enthusiasm. These patterns do not rule out a contribution from novelty or engagement, and future studies should include explicit measures of treatment fidelity, instructor equivalence, and engagement over time to disentangle these explanations more directly.

The findings have practical implications for fine arts higher education. AR may be especially useful for topics involving perspective, foreshortening, proportion, volume, and spatial relationships. Lecturers can integrate AR before and during figure drawing to support observation from multiple viewpoints, but AR should remain complementary to drawing practice, lecturer demonstration, critique, and feedback. Effective implementation also requires attention to device compatibility, camera quality, lighting, and students' familiarity with AR.

Several limitations constrain interpretation. First, the study involved a limited sample from one institution and used intact classes, which restricts generalizability and causal inference. Because assignment to the AR-supported or conventional condition followed pre-existing class membership rather than randomization, selection bias remains possible, and the single-institution, single-discipline sample limits the ecological validity of the findings beyond this specific studio context. Second, the intervention period was relatively short and no delayed post-test was included, so the durability of improvement is unknown. Third, visual-spatial development was inferred from discipline-specific drawing dimensions rather than measured with an independent standardized spatial ability instrument. Fourth, inter-rater reliability for the drawing rubric and internal consistency for the perception questionnaire were not reported. This leaves open the possibility of instrumentation effects, such as rater drift between the pre-test and post-test scoring sessions. Fifth, the large effect sizes should be interpreted cautiously because they were obtained in a controlled classroom context with a modest sample. Sixth, because both groups were aware they were part of a comparative study, a Hawthorne effect cannot be ruled out, and unequal access to AR-capable devices could limit the external validity of the findings in less-resourced settings. Future studies should use larger multi-site samples, longer interventions, stronger instrument validation, inter-rater reliability evidence, independent spatial measures, and longitudinal follow-up.

Conclusions

This study found that AR-supported artistic anatomy learning was associated with greater improvement in fine arts students' figure drawing performance than conventional instruction. The largest differences were observed in perspective and spatial coherence, indicating that AR was particularly useful for visual-spatial aspects of figure drawing. Students also reported high usability, engagement, and pedagogical value, and qualitative findings showed that they used rotation, scaling, and multi-angle exploration to examine three-dimensional bodily form before translating it into drawings. The study extends AR-supported anatomy learning from medical and science contexts into fine arts studio pedagogy. Its main contribution is to show that AR can support discipline-specific artistic performance when its affordances are aligned with the requirements of the studio task. AR should therefore be treated as a complementary pedagogical tool rather than a replacement for conventional studio practice, lecturer guidance, critique, and repeated drawing. For implementation, lecturers should integrate AR into structured activities that require students to observe, analyze, draw, compare, and revise. Institutions should also consider device compatibility and environmental conditions. Future research should strengthen the evidence base by reporting instrument reliability, using independent measures of spatial ability, testing longer interventions, and replicating the study across institutions and artistic contexts. These priorities directly reflect the limitations noted in the Discussion (Section 4), particularly regarding instrument reliability, baseline equivalence testing, and design constraints associated with intact-group assignment.

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References

Akkus, I., & Arslan, P. (2022). The effects of augmented reality in the technical drawing course on engineering students' spatial ability and academic achievement. Journal of Learning and Teaching in Digital Age, 7. https://doi.org/10.53850/joltida.1020075

Al-Amri, S., Hamid, S., Noor, N. F. M., & Gani, A. (2023). A framework for designing interactive mobile training course content using augmented reality. Multimedia Tools and Applications, 82(20), 30491–30541. https://doi.org/10.1007/s11042-023-14561-4

Alturki, U., & Aldraiweesh, A. (2023). Integrated TTF and self-determination theories in higher education: The role of actual use of massive open online courses. Frontiers in Psychology, 14, 1108325. https://doi.org/10.3389/fpsyg.2023.1108325

Álvarez-Marín, A., & Velázquez-Iturbide, J. Á. (2021). Augmented reality and engineering education: A systematic review. IEEE Transactions on Learning Technologies, 14(6), 817–831. https://doi.org/10.1109/TLT.2022.3144356

Baltaci, S., & Çetin, S. (2022). The effect of augmented reality on achievement and spatial visualization skills in technical drawing course. Journal of Learning and Teaching in Digital Age, 7. https://doi.org/10.53850/joltida.1047477

Bölek, K. A., De Jong, G., & Henssen, D. (2021). The effectiveness of the use of augmented reality in anatomy education: A systematic review and meta-analysis. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-94721-4

Cevikbas, M., Bulut, N., & Kaiser, G. (2023). Exploring the benefits and drawbacks of AR and VR technologies for learners of mathematics: Recent developments. Systems, 11(5), 244. https://doi.org/10.3390/systems11050244

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

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). SAGE Publications.

Faqih, K. M. S., & Jaradat, M.-I. R. M. (2021). Integrating TTF and UTAUT2 theories to investigate the adoption of augmented reality technology in education: Perspective from a developing country. Technology in Society, 67, 101787. https://doi.org/10.1016/j.techsoc.2021.101787

Fahrni, S., & Sabatasso, S. (2025). 3D modelling in anatomy teaching: State of the art and pilot investigations for its application. Translational Research in Anatomy, 41, 100444. https://doi.org/10.1016/j.tria.2025.100444

García-Robles, P., Cortés-Pérez, I., Nieto-Escámez, F. A., García-López, H., Obrero-Gaitán, E., & Osuna-Pérez, M. C. (2024). Immersive virtual reality and augmented reality in anatomy education: A systematic review and meta-analysis. Anatomical Sciences Education, 17(3), 514–528. https://doi.org/10.1002/ase.2397

Ghobadi, M., Shirowzhan, S., Ghiai, M. M., Mohammad Ebrahimzadeh, F., & Tahmasebinia, F. (2023). Augmented reality applications in education and examining key factors affecting users' behaviors. Education Sciences, 13(1), 10. https://doi.org/10.3390/educsci13010010

Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. MIS Quarterly, 19(2), 213–236.

González-Zamar, M.-D., & Abad-Segura, E. (2020). Implications of virtual reality in arts education: Research analysis in the context of higher education. Education Sciences, 10(9), 225. https://doi.org/10.3390/educsci10090225

Hui, J., Zhou, Y., Oubibi, M., Di, W., Zhang, L., & Zhang, S. (2022). Research on art teaching practice supported by virtual reality technology in primary schools. Sustainability, 14(3), 1246. https://doi.org/10.3390/su14031246

Kolb, D. A. (2015). Experiential learning: Experience as the source of learning and development (2nd ed.). Pearson Education.

Li, G., Luo, H., Chen, D., Wang, P., Yin, X., & Zhang, J. (2025). Augmented reality in higher education: A systematic review and meta-analysis of the literature from 2000 to 2023. Education Sciences, 15(6), 678. https://doi.org/10.3390/educsci15060678

Mao, Y., & Ling, J. (2025). Innovative applications of virtual reality in art and design education. Journal of Cases on Information Technology, 27(1). https://doi.org/10.4018/JCIT.382567

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

Minouei, M., Omid, A., Mirzaei, A., Mahdavifard, H., & Rahimi, A. (2024). Effectiveness of virtual reality on medical students' academic achievement in anatomy: Systematic review. BMC Medical Education, 24. https://doi.org/10.1186/s12909-024-06402-1

Panadero, E., Jonsson, A., Pinedo, L., & Fernández-Castilla, B. (2023). Effects of rubrics on academic performance, self-regulated learning, and self-efficacy: A meta-analytic review. Educational Psychology Review, 35(4), 113. https://doi.org/10.1007/s10648-023-09823-4

Sakti, H. G., & Abdurrahman. (2026). Powtoon animation effects on ICT learning interest: A madrasah experiment in Indonesia. Journal of Educational Studies, 4(1), 407–416. https://doi.org/10.58218/jes.v4i1.3563

Salimi, S., Asgari, Z., Mohammadnejad, A., Teimazi, A., & Bakhtiari, M. (2024). Efficacy of virtual reality and augmented reality in anatomy education: A systematic review and meta-analysis. Anatomical Sciences Education, 17(9), 1668–1685. https://doi.org/10.1002/ase.2501

Samala, A. D., Usmeldi, Taali, Daineko, Y., Indarta, Y., Nando, Y., Anwar, M., Jaya, P., & Almasri. (2023). Global publication trends in augmented reality and virtual reality for learning: The last twenty-one years. International Journal of Engineering Pedagogy, 13, 109–128. https://doi.org/10.3991/ijep.v13i2.35965

Schön, D. A. (1983). The reflective practitioner: How professionals think in action. Basic Books.

Wati, S. R., Bektiarso, S., Hilmi, M. I., & Budiarso, A. S. (2026). Augmented reality based on contextual problem scenarios on problem solving ability and cognitive level of elementary school students. Journal of Educational Studies, 4(2), 732–743. https://doi.org/10.58218/jes.v4i2.3124

Yang, Y., Du, W., Mavrikis, M., & Geraniou, E. (2025). Spatial skill development through augmented reality in mathematics education: A scoping review. Digital Experiences in Mathematics Education. https://doi.org/10.1007/s40751-025-00187-8

Yusuf, F. (2025). Investigating the impact of augmented reality-integrated project-based learning on university students' creative innovation, computational thinking, and academic resilience. Journal of Pedagogical Research, 9. https://doi.org/10.33902/JPR.202537068