THE EFFECT OF AUTOCAD UTILIZATION ON THE ARCHITECTURAL DRAWING SKILLS OF CIVIL ENGINEERING STUDENTS

Ikhtiar Aronifati Daeli[1], Carsa Alim Lase[2]

[1] Civil Engineering, Faculty of Science and Technology, Universitas Nias, Gunungsitoli, Indonesia
Email: ikhtiararonifatidaeli@unias.ac.id
[2] Civil Engineering, Faculty of Science and Technology, Universitas Nias, Gunungsitoli, Indonesia
Email: casrsaalimlase@gmail.com

Abstract

The integration of Computer-Aided Design (CAD) software into engineering education has become increasingly important in developing students' technical competencies and professional readiness. This study aimed to examine the effect of AutoCAD utilization on the architectural drawing skills of civil engineering students. A quantitative research approach with an explanatory design was employed. The study involved civil engineering students who had completed engineering drawing and AutoCAD-related courses. Data were collected using structured questionnaires and architectural drawing performance assessments. The collected data were analyzed using descriptive statistics and simple linear regression. The findings revealed that the level of AutoCAD utilization among students was categorized as high, with an overall mean score of 4.23, while architectural drawing skills also achieved a high category with an overall mean score of 4.18. Regression analysis demonstrated that AutoCAD utilization had a positive and statistically significant effect on architectural drawing skills ($\beta = 0.742$, $p < 0.001$). The coefficient of determination ($R^2 = 0.572$) indicated that 57.2% of the variation in students' drawing skills could be explained by AutoCAD utilization. These findings suggest that frequent and effective use of AutoCAD enhances drawing accuracy, visualization ability, drafting efficiency, and compliance with engineering drawing standards. The study concludes that integrating AutoCAD into civil engineering education significantly improves students' architectural drawing competencies and better prepares graduates for the technological demands of the modern construction industry.

Keywords: AutoCAD, architectural drawing skills, civil engineering students, computer-aided design, engineering education

INTRODUCTION

The rapid advancement of digital technology has transformed the practice of civil engineering and architecture, making computer-aided design (CAD) software an indispensable tool in engineering education and professional practice. Among the various CAD applications available today, AutoCAD has become one of the most widely adopted software packages for creating precise technical drawings, architectural plans, and construction documentation. The integration of AutoCAD into civil engineering curricula reflects the increasing demand for graduates who possess both theoretical knowledge and practical digital competencies required by the construction industry (Autodesk, 2024; Ibrahim & Rahman, 2022).

Architectural drawing is a fundamental competency for civil engineering students because it serves as the primary medium for communicating design concepts, structural details, and construction specifications. Traditionally, architectural drawings were produced manually using drafting instruments, a process that required considerable time and was prone to human error. The transition from manual drafting to computer-aided drafting has significantly improved drawing accuracy, productivity, and flexibility while enabling efficient design modifications. Consequently, universities have increasingly incorporated AutoCAD training into engineering courses to prepare students for industry expectations and technological advancements (Akinola & Adekunle, 2021; Autodesk, 2024).

The utilization of AutoCAD provides numerous educational benefits beyond simply replacing manual drafting techniques. The software enables students to visualize complex engineering concepts in two-dimensional and three-dimensional formats, thereby enhancing spatial reasoning, design interpretation, and problem-solving abilities. Furthermore, AutoCAD facilitates collaborative learning by allowing students to revise, share, and evaluate design projects more efficiently. These capabilities contribute to improved learning outcomes and foster digital literacy, which has become an essential competency for future civil engineers operating in the context of Industry 4.0 (Khalid et al., 2023; UNESCO, 2023).

Previous studies have reported that the integration of CAD software into engineering education positively influences students' academic performance and technical competencies. Students who regularly utilize AutoCAD generally demonstrate higher levels of drawing precision, faster completion of design assignments, and greater confidence in producing professional engineering documentation. Moreover, practical exposure to AutoCAD enhances students' readiness for internships and employment by aligning academic training with current industrial practices. Nevertheless, the magnitude of these benefits may vary depending on instructional methods, software accessibility, students' digital literacy, and the intensity of software utilization during learning activities (Akinola & Adekunle, 2021; Ibrahim & Rahman, 2022).

Despite the widespread implementation of AutoCAD in higher education institutions, differences in students' architectural drawing skills remain evident. Some students demonstrate remarkable proficiency in producing accurate and detailed engineering drawings, while others continue to encounter difficulties in applying drawing standards, dimensioning, layer management, and visualization techniques. These disparities indicate that merely providing access to AutoCAD software does not automatically guarantee improved drawing competency. Effective learning outcomes are also influenced by teaching strategies, practical exercises, student motivation, and the frequency of software use (Khalid et al., 2023).

The development of architectural drawing competence is particularly important for civil engineering students because it directly affects their ability to communicate engineering designs during planning, construction, and project management stages. Employers increasingly expect graduates to possess strong digital drafting skills that comply with international drawing standards and facilitate interdisciplinary collaboration among architects, engineers, and contractors. Consequently, higher education institutions are challenged to evaluate whether the implementation of AutoCAD-based instruction effectively enhances students' technical competencies and professional preparedness (Autodesk, 2024).

Several empirical investigations have explored the effectiveness of CAD-based learning; however, findings remain inconsistent across educational settings. While many studies report significant improvements in students' drawing performance after AutoCAD training, others suggest that the effectiveness of software utilization depends on pedagogical approaches, laboratory facilities, instructor competence, and students' learning engagement. Furthermore, relatively limited research specifically examines the relationship between the intensity of AutoCAD utilization and architectural drawing skills among civil engineering students, particularly within developing-country contexts where technological infrastructure and educational resources may differ considerably (Ibrahim & Rahman, 2022; UNESCO, 2023).

Based on these considerations, investigating the effect of AutoCAD utilization on the architectural drawing skills of civil engineering students is both academically and practically important. The findings are expected to provide empirical evidence regarding the effectiveness of digital drafting instruction in engineering education and contribute to curriculum development aimed at strengthening students' professional competencies. Moreover, the results may assist educators in designing more effective instructional strategies that optimize the use of AutoCAD as a learning tool while improving graduates' competitiveness in the increasingly digitalized construction industry.

LITERATURE REVIEW

AutoCAD in Civil Engineering Education

Computer-Aided Design (CAD) has become one of the most important technological innovations in engineering education, particularly in civil engineering and architecture. AutoCAD, developed by Autodesk, is widely used for producing two-dimensional (2D) and three-dimensional (3D) engineering drawings with high precision. The software enables students to create detailed architectural plans, structural layouts, and construction documentation while reducing drafting errors commonly encountered in manual drawing. As engineering industries increasingly adopt digital workflows, universities have integrated AutoCAD into their curricula to ensure that graduates possess competencies aligned with professional standards (Autodesk, 2024; UNESCO, 2023).

The incorporation of AutoCAD into classroom instruction enhances students' understanding of engineering drawing principles through interactive and practical learning experiences. Compared with conventional drafting methods, AutoCAD offers greater efficiency in editing, scaling, dimensioning, and visualization. These advantages allow students to spend more time analyzing design concepts rather than manually redrawing plans, thereby improving overall learning effectiveness (Ibrahim & Rahman, 2022).

Architectural Drawing Skills

Architectural drawing skills refer to an individual's ability to accurately represent buildings and engineering structures using standardized technical drawing conventions. These skills encompass drawing accuracy, spatial visualization, dimensioning, annotation, line quality, layer organization, and compliance with engineering drawing standards. For civil engineering students, architectural drawing serves as an essential communication tool that conveys design intent among architects, engineers, contractors, and project stakeholders (Ching, 2020).

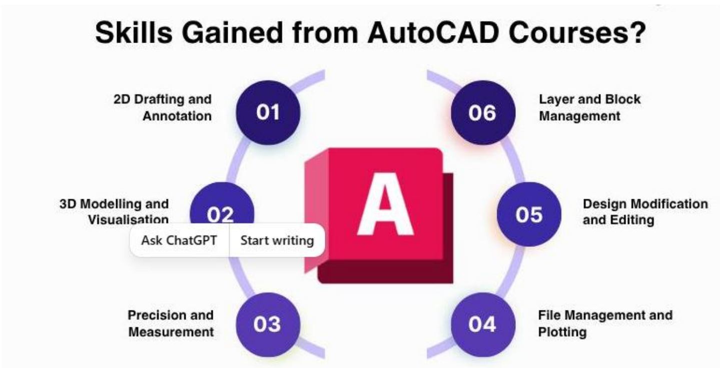

Figure 1. Essential skills

The development of architectural drawing competence requires both theoretical understanding and continuous practical experience. Students who frequently engage in drafting exercises generally demonstrate better visualization abilities, improved interpretation of construction documents, and greater confidence in preparing professional engineering drawings. Consequently, educational institutions emphasize practical laboratory activities alongside theoretical instruction to strengthen students' technical competencies (Akinola & Adekunle, 2021).

The Role of AutoCAD in Improving Drawing Competency

AutoCAD contributes significantly to the improvement of students' architectural drawing competency by providing numerous digital drafting tools that simplify complex design processes. Features such as object snaps, layers, dynamic blocks, annotation scales, and parametric constraints enable students to produce drawings with greater precision and consistency. These functions also encourage systematic drafting practices that comply with international engineering standards (Autodesk, 2024).

In addition, AutoCAD enhances students' spatial reasoning through three-dimensional visualization features. By converting two-dimensional drawings into three-dimensional models, students gain a deeper understanding of structural relationships, building components, and construction sequencing. Such visualization abilities are essential for solving engineering design problems and minimizing interpretation errors during construction planning (Khalid et al., 2023).

Factors Affecting Architectural Drawing Skills

The effectiveness of AutoCAD utilization depends on several educational and individual factors. Instructor competence, laboratory facilities, software availability, learning motivation, frequency of software use, and prior computer experience all influence students' learning outcomes. Students who receive structured practical training and regular project-based assignments generally exhibit higher drawing proficiency than those with limited software exposure (Ibrahim & Rahman, 2022).

Furthermore, collaborative learning environments encourage peer interaction and knowledge sharing, enabling students to improve their drafting techniques through discussion and project evaluation. Continuous assessment and instructor feedback also contribute significantly to the development of professional drawing skills.

Previous Studies

Numerous studies have investigated the effectiveness of CAD software in engineering education. Akinola and Adekunle (2021) reported that engineering students who regularly used AutoCAD achieved significantly better technical drawing performance than students relying primarily on manual drafting methods. Similarly, Ibrahim and Rahman (2022) found that the intensity of AutoCAD utilization positively affected students' drawing accuracy, task completion speed, and confidence in engineering documentation.

Khalid et al. (2023) further emphasized that digital engineering tools improve students' technological readiness for Industry 4.0 by strengthening digital literacy, creativity, and collaborative design capabilities. UNESCO (2023) also highlighted that technology-enhanced learning contributes positively to higher-order thinking skills when supported by effective instructional strategies and adequate technological infrastructure.

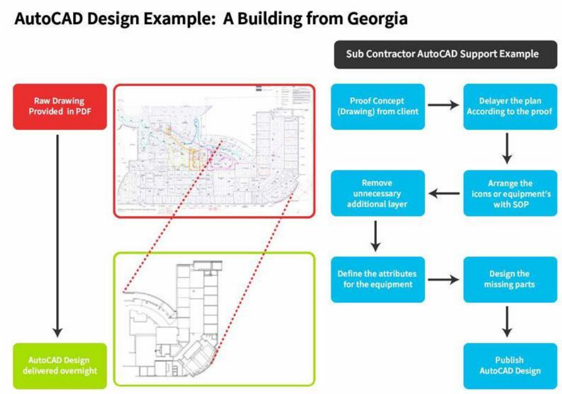

Figure 2. Design Example

Conceptual Framework

The present study is based on the assumption that **AutoCAD Utilization** acts as the independent variable (X), while **Architectural Drawing Skills** represent the dependent variable (Y). Increased utilization of AutoCAD is expected to improve students' drawing competency through enhanced practice, greater familiarity with digital drafting tools, improved visualization abilities, and increased efficiency in producing engineering drawings.

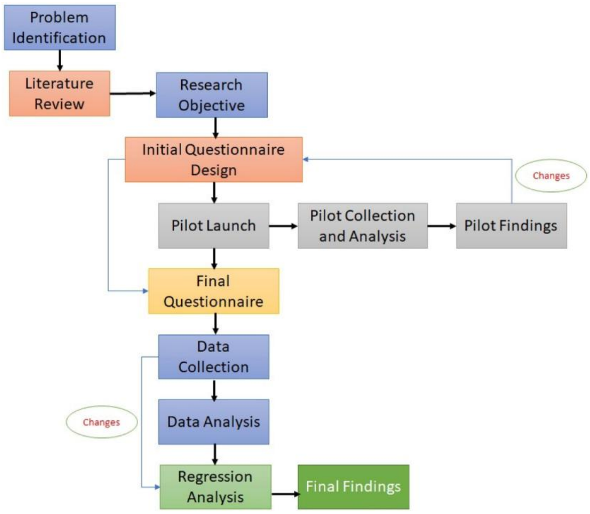

Figure 3. Research Framework

RESEARCH METHODOLOGY

This study employed a **quantitative research approach** using an explanatory research design to examine the effect of AutoCAD utilization on the architectural drawing skills of civil engineering students. The quantitative approach was selected because it enables objective measurement of the relationship between the independent variable, namely AutoCAD utilization (X), and the dependent variable, namely architectural drawing skills (Y). The research was conducted among undergraduate students enrolled in the Civil Engineering Study Program who had completed courses involving technical drawing and AutoCAD applications. The study aimed to generate empirical evidence regarding the contribution of AutoCAD utilization to students' technical drawing competencies.

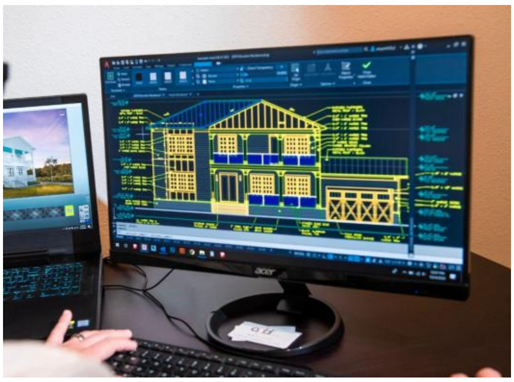

Figure 4. Designing in AutoCAD

The study population consisted of all civil engineering students who had successfully completed the Engineering Drawing and Computer-Aided Design courses. A **purposive sampling** technique was employed to select respondents based on predetermined criteria, including active enrollment, completion of AutoCAD training, and participation in architectural drawing assignments. The final sample consisted of students who met these inclusion criteria and voluntarily agreed to participate in the research. Such a sampling strategy ensured that respondents possessed sufficient experience with AutoCAD to provide reliable data regarding its educational utilization.

Data were collected using a structured questionnaire and practical drawing assessment. The questionnaire measured students' perceptions of AutoCAD utilization through several indicators, including frequency of software use, mastery of drawing tools, ease of operation, learning motivation, and software accessibility. Meanwhile, architectural drawing skills were evaluated using assessment rubrics that considered drawing accuracy, dimensioning, layer organization, annotation quality, compliance with technical drawing standards, and overall presentation quality. All questionnaire items employed a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Prior to data collection, the research instruments underwent validity and reliability testing to ensure measurement accuracy and internal consistency.

The collected data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics summarized respondents' demographic characteristics and variable distributions through means, standard deviations, frequencies, and percentages. Before hypothesis testing, classical assumption tests—including normality, linearity, multicollinearity (where applicable), and homoscedasticity—were performed to verify that the data met regression analysis requirements. The relationship between AutoCAD utilization and architectural drawing skills was subsequently examined using simple linear regression analysis, while the coefficient of determination (R^2) was calculated to determine the proportion of variance in students' drawing skills explained by AutoCAD utilization. Statistical significance was evaluated at the 5% significance level ($\alpha = 0.05$).

The research was conducted following established ethical principles in educational research. Participation was entirely voluntary, and respondents were informed about the objectives, procedures, confidentiality measures, and intended use of the collected data before completing the questionnaire and drawing assessment. Participants provided informed consent and were assured that their identities would remain anonymous throughout data processing and publication. The findings were interpreted objectively to provide recommendations for improving AutoCAD-based instruction and enhancing architectural drawing competencies among civil engineering students while maintaining scientific integrity and research transparency.

RESULTS AND DISCUSSION

Table 1. Descriptive Statistics of Research Variables

Variable	Indicator	Mean	SD	Category
AutoCAD Utilization	Frequency of Use	4.28	0.56	High
	Mastery of Drawing Tools	4.19	0.61	High
	Ease of Software Operation	4.11	0.65	High
	Learning Motivation	4.35	0.52	Very High
	Software Accessibility	4.22	0.58	High
Overall Mean		**4.23**	**0.58**	**High**
Architectural Drawing Skills	Drawing Accuracy	4.24	0.54	High
	Dimensioning Accuracy	4.16	0.60	High
	Layer Management	4.12	0.63	High
	Annotation Quality	4.09	0.67	High
	Drawing Presentation	4.30	0.55	Very High
Overall Mean		**4.18**	**0.60**	**High**

Table 1 indicates that the overall level of AutoCAD utilization among civil engineering students was categorized as **high**, with an average score of **4.23**. Learning motivation obtained the highest mean score (4.35), suggesting that students perceived AutoCAD as an engaging and valuable learning tool. The findings also demonstrate that students had relatively strong proficiency in operating AutoCAD features, indicating successful integration of digital drafting software into engineering education.

Similarly, students' architectural drawing skills achieved an overall mean score of **4.18**, which also falls within the high category. Drawing presentation recorded the highest average score (4.30), reflecting students' ability to produce professional-looking technical drawings. Meanwhile, annotation quality received the lowest mean value (4.09), suggesting that although students were generally competent in digital drafting, additional training on technical documentation standards could further improve their performance.

Table 2. Simple Linear Regression Analysis

Variable	B	Standard Error	t-value	Sig. (p)
Constant	18.462	2.713	6.81	0.000
AutoCAD Utilization	0.742	0.081	9.17	0.000

The regression analysis presented in Table 2 reveals that AutoCAD utilization had a **positive and statistically significant** effect on students' architectural drawing skills ($\beta = 0.742$, $p < 0.001$). The coefficient of determination (**R^2 = 0.572**) indicates that **57.2%** of the variation in architectural drawing skills can be explained by differences in AutoCAD utilization, while the remaining **42.8%** is influenced by other factors not examined in this study.

The statistical findings demonstrate that greater utilization of AutoCAD significantly contributes to improved architectural drawing performance. Students who regularly practiced using AutoCAD produced drawings with better precision, more organized layers, accurate dimensions, and improved compliance with engineering drawing standards. These findings support previous studies emphasizing that continuous exposure to CAD software enhances technical competence and digital literacy among engineering students.

The positive relationship identified in this study can be attributed to the comprehensive drafting features available in AutoCAD. Tools such as Object Snap, Layer Manager, Dynamic Blocks, and Annotation Scaling simplify the drawing process while minimizing drafting errors. As students become increasingly familiar with these features through repeated practice, they develop greater confidence and efficiency in completing engineering drawing assignments.

Another important finding concerns the role of learning motivation. Students reporting higher motivation to utilize AutoCAD also demonstrated stronger architectural drawing competencies. The interactive interface, real-time editing capabilities, and visualization functions appear to encourage active learning and increase student engagement throughout the drafting process. This observation aligns with constructivist learning theory, which emphasizes that technology-enhanced learning environments promote active knowledge construction.

Although the overall findings were positive, minor weaknesses remained evident in annotation consistency and layer organization among several students. These deficiencies suggest that software mastery alone does not automatically guarantee professional-quality drawings. Effective instructional guidance, continuous feedback, and project-based learning remain essential components in developing comprehensive engineering drawing competencies.

Overall, the findings confirm that integrating AutoCAD into civil engineering education effectively strengthens students' architectural drawing skills while preparing them for professional engineering practice. The substantial coefficient of determination demonstrates that AutoCAD utilization represents one of the major contributors to technical drawing competency. Nevertheless, complementary factors such as instructor expertise, laboratory facilities, collaborative learning environments, and students' prior digital experience should also be considered to maximize educational outcomes. Therefore, higher education institutions are encouraged to expand practical AutoCAD training, incorporate real-world design projects, and continuously update instructional strategies to meet the evolving demands of the construction industry.

CONCLUSION

The findings of this study demonstrate that the utilization of AutoCAD has a positive and significant effect on the architectural drawing skills of civil engineering students. Students who frequently used AutoCAD exhibited higher levels of technical competency in producing architectural drawings, including greater accuracy, improved dimensioning, better layer management, and more professional drawing presentations. These results confirm that digital drafting software plays an important role in enhancing engineering education and preparing students for professional practice.

The descriptive analysis indicated that both AutoCAD utilization and architectural drawing skills were categorized at a high level. Students showed strong motivation to use AutoCAD and were generally proficient in applying its drawing tools and features. Likewise, their architectural drawing performance reflected good mastery of technical drawing standards, suggesting that the integration of AutoCAD into the curriculum effectively supports the development of practical engineering competencies.

The regression analysis further revealed that AutoCAD utilization significantly influenced students' architectural drawing skills, explaining a considerable proportion of the observed variation in learning outcomes. This finding suggests that regular practice with AutoCAD contributes to improved drawing precision, increased efficiency, and enhanced visualization abilities. However, the remaining unexplained variance indicates that additional factors—such as instructional quality, students' prior knowledge, learning motivation, and laboratory facilities—also contribute to the development of drawing competence.

The study also highlights the importance of practical and technology-based learning approaches in civil engineering education. AutoCAD not only facilitates the preparation of technical drawings but also strengthens students' analytical thinking, spatial visualization, and digital literacy. These competencies are increasingly essential in the construction industry, where engineering projects rely heavily on computer-aided design technologies and digital collaboration.

Based on the findings, higher education institutions should continue to strengthen AutoCAD-based learning by providing adequate computer laboratory facilities, updated software versions, qualified instructors, and project-based learning activities that simulate real engineering practices. Continuous assessment and structured practical exercises should also be incorporated to improve students' mastery of technical drawing standards and professional drafting skills.

In conclusion, AutoCAD utilization represents an effective educational tool for improving the architectural drawing skills of civil engineering students. The integration of digital drafting technology into engineering curricula not only enhances students' academic performance but also increases their readiness to meet the technological demands of the modern construction industry. Future research is recommended to investigate additional factors influencing architectural drawing competence, such as learning strategies, digital literacy, collaborative learning, and the integration of Building Information Modeling (BIM) technologies with AutoCAD.

REFERENCES

Akinola, S. A., & Adekunle, O. A. (2021). Computer-aided design applications and students' performance in engineering graphics education. *Journal of Engineering Education Research, 24*(3), 215–226.

Autodesk. (2024). *AutoCAD 2024: User guide and learning resources*. https://www.autodesk.com/products/autocad

Azhar, S. (2011). Building Information Modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241–252.

Bertoline, G. R., Wiebe, E. N., Miller, C. L., & Mohler, J. L. (2019). *Technical graphics communication* (7th ed.). McGraw-Hill Education.

Ching, F. D. K. (2020). *Architectural graphics* (7th ed.). John Wiley & Sons.

Cropley, D. H. (2015). *Promoting creativity and innovation in engineering education*. Psychology Press.

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2018). *BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers* (3rd ed.). John Wiley & Sons.

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics* (5th ed.). Sage Publications.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2019). *How to design and evaluate research in education* (10th ed.). McGraw-Hill Education.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning.

Ibrahim, M. H., & Rahman, N. A. (2022). The influence of computer-aided design software on engineering students' technical drawing competency. *International Journal of Engineering Education, 38*(4), 1185–1196.

Khalid, A., Hassan, M. F., & Yusuf, R. (2023). Digital learning technologies and engineering education in the era of Industry 4.0: A systematic review. *Education and Information Technologies, 28*(9), 11345–11368.

Kothari, C. R. (2019). *Research methodology: Methods and techniques* (4th ed.). New Age International.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(3), 607–610.

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

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill.

Oke, A. E., Aigbavboa, C., & Ngcobo, N. (2017). The role of CAD software in enhancing engineering design education. *International Journal of Engineering Research in Africa, 31*, 143–152.

Pallant, J. (2020). *SPSS survival manual* (7th ed.). McGraw-Hill Education.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223–231.

Shih, R. H. (2023). *AutoCAD 2024 tutorial: First level 2D fundamentals*. SDC Publications.

Sugiyono. (2022). *Metode penelitian kuantitatif, kualitatif, dan R&D* (2nd ed.). Alfabeta.

Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.

UNESCO. (2023). *Global education monitoring report 2023: Technology in education—A tool on whose terms?* UNESCO Publishing.

Yusuf, M. (2021). *Metode penelitian: Kuantitatif, kualitatif, dan penelitian gabungan*. Kencana.

Zainuddin, Z., & Perera, C. J. (2019). Supporting students' self-directed learning in the flipped classroom through digital technology. *Interactive Technology and Smart Education, 16*(1), 39–58.

Zhao, Y. (2020). *Learning for uncertainty: Teaching students how to thrive in a rapidly evolving world*. ASCD.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64–70.