Migration Letters

Volume: 21, No: S4 (2024), pp. 727-742

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

Developing A Peer Instruction Framework For Teaching Technical Drawing In Technology-Based Education At Nigerian Universities

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Abstract

This study aimed to develop a peer instruction framework for enhancing technical drawing teaching in Nigerian Universities. The research explores the effectiveness of peer instruction in improving students' academic achievement in technical drawing. This comprehensive approach aims to contribute to the development of a well-designed instructional framework tailored to the unique educational context of technical drawing in Nigerian schools. The study employed the Delphi research strategy to establish a consensus about elements necessary for teaching technical drawing skills within peer instruction's independent and dependent learning phases. This effort culminated in formulating the Four D Model (4-D model), encompassing planning, independent learning, dependent learning, and evaluation. This model serves as a structured guide for the effective teaching and learning of technical drawing in peer instruction classes. To assess and understand the interrelated factors, we integrated Structural Equation Modeling (SEM), a statistical technique facilitating the testing and evaluation of multivariate causal relationships. SEM enabled a holistic comprehension of the considered variables. Subsequently, the insights from each stage informed the development of a scientifically grounded procedure for implementing peer instruction in teaching technical drawing skills within Nigerian Universities. The application of the 4-D model ensured the proficient execution of hands-on activities and teaching methodologies, promoting skill development. In conclusion, we strongly advocate for the widespread adoption of this research-based framework in Nigerian schools. Its implementation promises to enhance students' practical skill acquisition through an active learning process, thereby elevating the quality of technical drawing education.

Keywords*: Framework, Teaching, Technical Drawing, Peer Instruction, Independent Learning, Dependent Learning.*

1. Introduction

Technical drawing, or drafting, is a precise and detailed graphical representation of objects, structures, or systems (Smith & Doyle, 2018). Technical drawing helps convey complex ideas and designs in engineering and architecture, facilitating clear communication among students and professionals (Faraje & Sadiq, 2019). Similarly, technical drawing forms the foundation of our modern world, contributing to architectural, mechanical, and civil advancements (Faraje & Sadiq, 2019). In engineering, technical drawings provide accurate dimensions and measurements for drafting and designing processes (Siminialayi & Fomsi, 2023). Designers benefit from[1] technical drawing as it offers a reference for 3D modelling, ensuring precision and accuracy in their creations (Gómez-Tone et al., 2021). Studies reveal

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that conventional lectures in most Nigerian schools lead to passive learning, limiting student engagement and interaction with the technical drawing subjects (Deshpande & Huang, 2011; Onwe & Uwaleke, 2018).

Furthermore, research shows passive teaching challenges understanding technical drawing concepts (P. Chijioke et al., 2019). Students may struggle to grasp complex technical drawing concepts through traditional teaching methods, hindering effective learning (Workie, 2020). Research comparing conventional methods and innovative pedagogies emphasises the importance of exploring alternative teaching approaches in technical drawing (P. Chijioke et al., 2019; Zhang et al., 2020). Therefore, this study aims to enhance technical drawing education by transitioning to an active teaching method through peer instruction. Empirical evidence supports choosing peer instruction over conventional methods for technical drawing instruction. The active learning fostered by peer instruction could encourage students to engage actively with technical drawing concepts (Crouch & Mazur, 2001). This participation enhances comprehension and skill acquisition in comparison to passive learning methods.

Similarly, the immediate feedback mechanism of peer instruction could aid technical drawing students in receiving feedback from their peers during discussions, assisting in promptly correcting misconceptions (Mazur, 2014). This real-time feedback could contribute to a more effective learning process. Also, peer instruction, critical thinking, a social learning environment, retention of material, and a student-centred approach provide the rationale for choosing Peer Instruction for Technical Drawing education in this study (Tullis & Goldstone, 2020).

The existing instructional approaches for technical drawing in Nigeria do not fully address conventional teaching methods' challenges (Workie, 2020). Therefore, there is an urgent need for a more effective peer instructional framework in technical drawing. This framework should align with modern educational practices, incorporate technological innovations, and focus on the skills required by technical drawing students (Schell & Butler, 2018). As technical drawing plays a vital role in shaping students' understanding of complex structures and designs, an enhanced instructional framework is essential for fostering the acquisition of practical skills and meeting the demands of contemporary technical education.

1.1 Theoretical Framework

This study is grounded in John Dewey's Experiential Learning Theory (ELT) from 1969. According to Dewey, learning involves a continuous reconstruction of experience, leading to knowledge modification (Grady & Role, 2003). ELT delineates two interlinked modes of experience grasping (Concrete Experience, CE, and Abstract Conceptualization, AC) and two connected modes of experience transformation (Reflective Observation, RO, and Active Experimentation, AE) (Kolb, 2012). The learning process resolves creative tensions among these four modalities, guiding learners through a cyclical exploration of experience, reflection, thinking, and action (Daniels & Cajander, 2010). Also, the learning process forms an idealised learning cycle or spiral, wherein thoughts stem from recent experiences, evolve into abstract concepts, and prompt new action implications (Grady & Role, 2003). This theory aligns with our study, emphasising creative and innovative thinking integration in psychomotor skills learning. Incorrect delivery of practical course content may lead to cognitive conflict, impacting students' learning outcomes. Students are encouraged to formulate problems, connect ideas, analyse situations, and observe the outcomes throughout the skills-learning process.

2. Literature Review

Research-based psychomotor skills training in technical drawing instruction has profoundly impacted learners' competence and outcomes. Studies such as analysing engineering students' psychomotor skill development and program outcome attainment have shown that tailored psychomotor training programs significantly enhance skills (Huang et al., 2020; Mat Isa et al., 2020). Thus, psychomotor skills are particularly relevant in technical drawing, where precise and controlled motor skills are paramount. The effectiveness of digitally instruction and evaluating psychomotor skills, particularly in medical head and neck examinations, has been demonstrated in remote learning environments, highlighting the versatility and accessibility of evidence-based methods (Mat Isa et al., 2020). Furthermore, collaborative skills, a subset of psychomotor abilities, have significantly contributed to the construction education domain, illustrating the broader impact on interdisciplinary applications (Setiawan et al., 2021; Wizaka & Nurdiani, 2018). Research-backed methods ensure a systematic and targeted approach to psychomotor skill development in technical drawing, improving precision and proficiency (Mat Isa et al., 2020). In summary, research-based psychomotor skills training in technical drawing can enhance individual skills, positively influence collaborative efforts, and adapt to digital learning environments. These findings underscore the importance of incorporating evidence-based pedagogical approaches to ensure the comprehensive development of technical drawing skills.

Research demands skills-intensive courses like technical drawing to embrace a holistic educational approach, integrating knowledge, skills, and attitudes (Dong et al., 2020; Gouda, 2022). Specifically, studies require initial exposure to a profound understanding of theoretical concepts relevant to the specific skill set (Dong et al., 2020). Subsequently, teaching involves the application of theoretical knowledge to real-world scenarios within the field of study (Gouda, 2022). The next step is education to cultivate proficiency in the technical skills associated with the course through hands-on training and practical application (Leask et al., 2020). The emphasis shifts to teaching practical problem-solving skills and adapting learned skills to diverse situations during this stage (Sinaga et al., 2023).

Educators in this phase cultivate a positive work attitude, highlighting motivation, resilience, and a proactive approach to overcoming challenges (Ko & Chung, 2014). Additionally, teachers should promote practical communication skills, teamwork, and adaptability (Lauana et al., 2022; Speranza et al., 2017). Lastly, educators must regularly assess students' prior knowledge and skills to tailor instruction effectively (Jimaa, 2011). The collective findings underscore the importance of fostering theoretical knowledge and positive attitudes in skills-intensive courses. The amalgamation of these elements ensures a comprehensive educational experience, preparing students for success in their chosen fields.

Researchers recommend a sequenced, stepped teaching approach for instructing psychomotor skills. This framework emphasises a structured and sequential method involving observation and perception to facilitate skill acquisition (Khadjooi et al., 2011). The process typically includes skill demonstration by the educator, verbal overlay of the skill steps, and active learner engagement to enhance performance (Oermann et al., 2016). This approach aligns with Gagne's instructional design model, rooted in the information processing model, and offers a systematic and effective method for teaching psychomotor skills (Khadjooi et al., 2011). Table 1 below presents relevant instructional frameworks for teaching psychomotor skills.

Table 1: Instructional Frameworks for Teaching Psychomotor Skills

Author	Order	Comment

Dave, 1975	Imitation, Manipulation, Refining, Articulation, and Naturalisation.	Suitable for accomplishing vocational objectives at the pre-vocational training stage (Venatius et al., 2023).
Harrow, 1972	Impulse movements, Ultimate Movements, Insight, Physical skills, Skilled Activities, Non-discursive Message.	The classifications lack exclusivity, with overlapping evident among both categories and subcategories. Consequently, the model falls short of providing a comprehensive definition of psychomotor education in TVET (O. Chijioke, 2013).
Padelford, 1984	Noticing, motivating, Imitating, Performing, Adapting, and Innovating	The model articulates learning objectives thoroughly, aligning with the need for diverse psychomotor behaviours (Venatius et al., 2023)
Fitts, 1964	Cognitive, Associative, Autonomous.	This model guides instructional design but is not explicit enough to state lesson objectives (Davids et al., 2008)
Bloom Taxonomy, 1956	Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation.	This model is suitable for creating diverse and achievable learning experiences (E. Adams, 2015)

As shown in Table 1, instructional frameworks provide a structured and practical approach to teaching psychomotor skills, ensuring comprehensive skill development and learner engagement. Many of the frameworks examined are unsuitable for guiding and instructing artisans at both the craft (secondary) and master craftsman (post-secondary) levels (Venatius et al., 2023). Exceptions are the Padeford (1984), Fitts (1964), and Bloom Taxonomy (1956) frameworks, which stand out for their comprehensive articulation of learning objectives. Research identifies Bloom's taxonomy as the most widely acknowledged for its versatility and breadth in formulating learning objectives across various domains and disciplines (E. Adams, 2015; Krathwohl, 2002). The taxonomy aids in establishing precise and measurable learning goals (E. Adams, 2015). Bloom's Taxonomy stands out as it organises learning objectives hierarchically, covering foundational knowledge recall and extending to advanced cognitive skills such as analysis and synthesis (Krathwohl, 2002).

Robert Gagne's Instructional Design Theory (IDT), introduced in 1965, confirmed the efficacy of Bloom's taxonomy as it also affirms that facts acquisition happens in defined education stages, each demanding tailored instructional methods (Khadjooi et al., 2011). The theory underscores the significance of a well-structured learning process for acquiring knowledge and skills (Venatius et al., 2023). According to IDT, optimal learning happens when students actively participate, guided by teachers who provide explanations, demonstrations, and corrective feedback for skill development (Vijayakumar et al., 2023). Therefore, we adopt Bloom's taxonomy and insight from IDT to guide the building of a relevant peer instruction model for technical drawing teaching in this study.

3. Methodology

3.1 Design

The research employed a three-division Delphi survey to advance consensus on the critical components of technical drawing skills suitable for integration into peer instruction (Keeney et al., 2011). The Delphi survey method collects interviewee views through cyclica, multi-level process in reaching a group agreement (Venatius et al., 2023). McGrane et al. (2014) and Sole et al. (2019) adopted this approach to establish consensus between diverse clusters regarding the optimal methods for teaching complex skills. The specific advantages offered by the Delphi survey are paramount to this study. The use of emails and Google Forms in this study ensures participant anonymity, provides time for thoughtful answers, and facilitates the engagement of people from diverse geographical locations and scholarly roles (Wamba & Ngai, 2012). Finally, the Delphi method employs statistical analysis for data summarization (Beiderbeck et al., 2021).

3.2 Participants

This study engaged 124 Technical Drawing educators, comprising both Lecturers and Instructors, from Nigerian Universities across five senatorial districts in Nigeria. Eligibility criteria required Technical Drawing educators with at least ten years of teaching experience in the field. We specifically chose Lecturers and Instructors (L & I) due to their direct involvement in implementing the Technical Drawing (TD) curriculum and teaching students. This hands-on experience positioned them to provide valuable insights into issues influencing the practical application of the peer instruction framework for TD teaching. The study utilised email and an online survey link to gather information from participants. Google Forms was employed to administer online questionnaires, ensuring the complete retrieval of questionnaires without missing data. The use of Google Forms for online questionnaires in this study was strategic, guaranteeing the comprehensive retrieval of questionnaires without any missing information. This approach enhances the reliability and wholeness of the collected data.

The participants demonstrated an advanced level of interest in the study results, being fully aware of the research objectives. Respondents, including Lecturers and Instructors, were recruited using consistent methods to ensure a uniform approach. Each round of the Delphi survey spanned three weeks, with an additional four-week open period (Irdayanti et al., 2015). This extended timeframe allowed for comprehensive input and thoughtful responses from the participants (Sekayi & Kennedy, 2017). In addition to survey responses, we collected detailed demographic information from participants. The information included gender, years of instruction/training experience, main area of practice, highest academic award, and current instruction/training post. To safeguard participant confidentiality, we employed a coded system to identify inquiries. All data kept on a password-protected digital system adhered to strict security protocols. Data extraction from Google Forms into the spreadsheet preceded the analysis phase. Utilising pattern analysis, a thematic approach, we developed a coding pattern grounded on a subdivision of data. This template was systematically applied to interpret and categorise open-ended responses, ensuring a robust scrutiny (Brooks et al., 2015).

As Aramide et al. (2015) recommended, the research team convened in person to ensure our study's robustness, engaging in comprehensive discussions about identified themes and their essential elements. Similarly, employing a two-phase model approach, as Clark and Creswell (2021) advocated, we generated themes after the coding exercise, undergoing meticulous revision in the ending phase before writing. This methodological strategy, recognised for enriching and fortifying studies, aligns with best practices. We meticulously gathered demographic information for each participant category in tandem with our thematic analysis, such as sex, age, length of service, and the highest academic award attained. Utilising the Kresije and Morgan Table, we extracted data from 124 Lecturers and Instructors in Nigerian Universities across five senatorial districts in Nigeria. The participant composition revealed a stark gender contrast, with 97.5% male and 2.5% female respondents. The gender disparity in this study aligns with existing studies highlighting lower female vocational and technical education enrollment in Nigerian schools (Idris & Rajuddin, 2013; Oluniyi et al., 2015). Most participants (82.5%) boasted over ten years of professional experience, with 53% surpassing 38 years. The breakdown of participants' qualifications reveals that 10.20% held a PhD, 37.80% possessed MSc/MEd, 42.50% had BSc/BEd/HND, and 9.50% held NCE/OND.

3.3 Data Analysis

In the initial phase, we conducted Confirmatory Factor Analysis (CFA) on each gauge, generating an output covariance matrix for subsequent modelling. We employed the Tucker-Lewis Index (TLI) and Comparative Fit Index (CFI) to assess the adequacy of measurement models within constrained degrees of freedom. Values around or above 0.90, as suggested by Barrett (2007), indicated a satisfactory fit. Additionally, we scrutinised factor loadings, ensuring they surpassed 0.40 for relevance. We assessed internal reliability using the Cronbach's alpha assessment. Following this, we calculated the means, standard deviations, and correlations of variables. To create a Structural Equation Model (SEM) for the entire sample, we employed the covariance matrix derived from Confirmatory Factor Analysis (CFA) in SEM models, using the original scale items as experiential variables.

In evaluating the model, we deemed a Root Mean Square Error of Approximation (RMSEA) below 0.05 as excellent, with an acceptable range extending up to approximately 0.08. Additionally, we consulted Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the ratio of chi-square to degrees of freedom (2/df) values, considering a fit as good when equal to or under 3, as recommended by Kline (2005). Also, we employ a multiple-group model to compare estimated effects for male and female teachers to analyse gender-specific impacts. Furthermore, we assessed measurement invariance by examining fit changes between configural, feeble invariance, and structural models. Similarly, we considered a tenable assumption of model invariance if $CFI\Delta \leq 0.015$ (Chen, 2007). Finally, we employ descriptive analysis of quantitative data involving occurrence count, percentage, and average statistics (refer to Table 4)

4. Result

The results of the Confirmatory Factor Analysis (CFA) reveal a lack of alignment with acceptable goodness-of-fit standards. Notably, key indicators like Chi-square (χ^2) = 310.002, Degrees of Freedom (Df) = 106, Goodness of Fit Index (GFI) = .668, Comparative Fit Index (CFI) = .609, Normed Fit Index (NFI) = .589, Tucker-Lewis Index (TLI) = .519, Incremental Fit Index (IFI) = .601, Root Mean Square Error of Approximation (RMSEA) = .266, Ratio of Chi-square to Degrees of Freedom (χ^2/Df) = 2.924, and P-value = 000 point to significant discrepancies. Importantly, none of these standardized estimate indicators demonstrate a strong fit with the data provided by respondents. Examining factor loadings for observed variables (items 1 to 10), with values such as 1 = 0.72, 2 = 0.69, 3 = 0.71, 4 = 0.81, 5 = .78, 6 = 0.72, 7 = 0.63, 8 = 0.65, 9 = 0.75, 10 = 0.67, met the threshold of 0.5, as per Awang (2014) guidelines for newly constructed items. Subsequently, two variables (11 and 12) with factor loadings below 0.5 were excluded. A subsequent repeat of Confirmatory Factor Analysis (CFA) validated the appropriateness of the modified data items for the teaching framework, aiming to enhance the overall model fit. Afterward, a multiple-group model evaluated the consistency of predicted effects for lecturers/instructors. Evaluations of modifications within the adjusted measurement model focused on testing standardized residual covariance, revealing values predominantly below two (2). According to Chen (2007), the calculated observed variables align with the recommended requirements of Structural Equation Modeling (SEM). This alignment is confirmed by the model's goodness-of-fit statistics, including an RMSEA value of 0.000 and CFI values of 0.007. These results affirm the appropriateness of the model for imparting technical drawing skills through peer instruction pedagogy in Nigerian universities.

Table 2 - Remaining Covariance of the Primary Measurement Model of the Peer Instruction Framework (PFK) for Teaching Technical Drawing Abilities

	PFK 12	PFK 11	PFK 10	PFK9	PFK 8	PFK 7	PFK 6	PFK 5	PFK 4	PFK 3	PFK 2	PFK 1
PFK 12	**-.965**											
PFK 11	**-.519**	**-.763**										
PFK 10	**-.232**	**-.848**	**.211**									
PFK 9	**-.181**	**-.090**	**.121**	**.721**								
PFK 8	**-1.344**	**-1.925**	**.515**	**.353**	**-1.837**							
PFK 7	**-1.235**	**-1.469**	**-.830**	**.071**	**-1.049**	**-1.736**						
PFK 6	**-1.859**	**-.064**	**-.941**	**.419**	**-2.546**	**-2.010**	**-1.081**					
PFK 5	**-2.343**	**-2.128**	**.908**	**.426**	**-1.682**	**-2.367**	**-.233**	**-1.078**				
PFK 4	**-2.052**	**-3.374**	**-1.31**	**.911**	**-2.038**	**-2.312**	**-1.677**	**-.634**	**-1.327**			
PFK 3	**-1.243**	**-.624**	**.226**	**.044**	**-2.359**	**-1.060**	**-1.467**	**-.931**	**-.260**	**-.618**		
PFK 2	**-3.272**	**-.819**	**.981**	**.921**	**-2.237**	**-1.470**	**-.184**	**.040**	**.138**	**.154**	**-.518**	
PFK 1	**-4.573**	**-3.020**	**.572**	**.337**	**-4.641**	**-4.673**	**-3.034**	**-3.284**	**-3.123**	**-2.165**	**-1.932**	**-4.58**

Table 3 - Mean, Standard Deviation, Correlation Matrix, and Cronbach's Alpha

Variables	**M**	**SD**	**α**	**1**	**2**	**3**
Planning	4.24	.67	.82			
Independent Learning	3.98	.58	.76	.38 ***		
Dependent Learning	4.89	.63	.81	.42 ***	.42 ***	
Evaluation	3.87	.66	.74	.36 ***	.38 ***	.29 ***

***p < .001, M = Mean, SD =Standard Deviation and α = Cronbach's alpha

Table 4 - Outcome of SEM analysis B

	B	**SE**	**β**
Planning	0.53	0.10	.32 ***
Independent Learning	0.56	0.09	.12 ***
	0.22	0.10	.09 *
Independent Learning	0.34	0.12	.10 ***
	0.22	0.11	.25 ***
Dependent Learning	0.40	0.07	.17 ***
Dependent Learning			

Dependent Learning	0.31	0.11	.09 ***
Evaluation	0.19	0.08	.28 ***
Evaluation	0.21	0.06	.15 ***
Evaluation	0.19	0.03	.34 ***
Evaluation			

***p < .001, *p < .05, **p < .01, B stands for "unstandardized beta,, " SE for "standard error," and for "standardized beta."

Table 5 - Analyzing Educators' Preferences for Integrating Elements into the Technical Drawing Peer Instructional Framework

S/N	**Statement**	**L & I %Agree**	**Mean**
1	Pre-Instructional Planning		
	i. Clearly Define Learning Objectives:	96.6	4.22
	ii. Select Appropriate Instructional Strategies.	98.7	3.69
	iii. Develop Comprehensive Assessment Plans.	96.9	3.90
	iv. Create a Supportive Learning Environment.	98.1	4.28
2	Independent Learning		
	i. Offer pre-class learning resources (online tutorials, instructional videos, and written guides)	97.3	4.24
	ii. Encourage peer teaching strategies.	96.7	3.33
	iii. Utilize interactive platforms that facilitate collaborative learning	97.5	3.97
3	Dependent Learning		
	i. Incorporate project-based learning methods.	95.2	3.86
	ii. Facilitate peer-assisted learning.	97.8	4.22
	iii. Identify the optimal group size in peer discussions.	98.0	4.00
4	Evaluation		
	i. Implement pre-class readiness assessment.	98.3	4.10
	ii. Conduct peer interaction observation.	96.6	4.21
	iii. Carry out conceptual understanding checks.	99.2	3.89
	iv. Incorporate practical problem-solving tasks.	96.2	4.33
	v. Assign pre-class reflective journals to encourage self-assessment.	94.3	4.12
	vi. Evaluate the impact of scaffolding strategies on student comprehension and skill development	94.9	3.98

We agreed on a 50% and above (=> 50%) benchmark to decide on elements acceptable for integration into the peer instruction framework for teaching technical drawing skills. In contrast, items with percentages less than 50 (< 50%) are regarded unacceptable for integration into PI for TD teaching in Nigerian schools. The assessment in this stage adopts the five (5) point Likert scale of strongly agree, agree, undecided, disagree, and strongly disagree. In this phase of evaluation, we employed a five-point Likert scale, encompassing options ranging from "strongly agree" to "strongly disagree."

5. Discussion

This research focuses on developing a robust peer instruction framework for teaching technical drawing in Nigerian Universities. The goal is to leverage peer interaction as a pedagogical tool, promoting deeper comprehension and mproving proficiency in technical drawing. The key finding of this research underscores the importance of incorporating pre-instructional planning, self-directed learning, guided learning, and assessment procedures as essential elements within a meticulously designed peer instruction framework aimed at teaching technical drawing. The study identified pre-instructional planning as a starting point for setting realistic objectives, selecting strategies, implementing assessments, and fostering a supportive learning environment for technical drawing teaching in peer instruction.

Findings from various studies reinforce the significance of pre-instructional planning in education (Ogunkola & Knight, 2018; Wizaka & Nurdiani, 2017). It allows educators to clearly define specific learning objectives, fostering a shared understanding between educators and students regarding expected lesson outcomes (dos Santos et al., 2018). Additionally, studies highlight that initial planning empowers educators to select instructional strategies, including collaborative activities, group discussions, and interactive exercises tailored for technical drawing and peer instruction (Kasemsap, 2017; Mazur, 2014). Also, separate research underscores the critical role of pre-instructional planning in aiding educators to develop assessments that promote peer interaction and collaborative problem-solving, aligning with the principles of peer instruction (Alnemr, 2020; Fernanda et al., 2018). Similarly, studies stress that initial planning enables instructors to shape the classroom environment and allocate resources, creating a supportive learning setting conducive to peer instruction in technical drawing teaching (Newsome et al., 2023; Rance et al., 2023).

Also, the study identified independent learning to gain basic technical drawing knowledge as the initial peer instruction phase. Specifically, the study found online tutorials, instructional videos, written guides, peer teaching methods, and interactive platforms to foster independent technical drawing learning in the pre-class part of peer instruction. In agreement with our findings, separate studies affirmed that self-instructional materials (SIM) enhance the pre-class phase of peer instruction by promoting individual understanding, facilitating collaborative learning, and optimising in-class activities (Jensen et al., 2018; Lee & Choi, 2019; Zhou, 2023). Self-instructional materials empower learners to grasp foundational concepts independently, preparing them for meaningful peer interactions during class (Jensen et al., 2018). Specifically, a study identified SIM as an instrument for developing Lower-Order Thinking Skills (LOTS) required for gaining fundamental knowledge and understanding (P. Legaspi & E. Pasia, 2021). Studies identified self-evident, self-sufficient, self-reliant, inspiring, and evaluative as SIM characteristics for effective learning (Loeng, 2020; P. Legaspi & E. Pasia, 2021). Therefore, research shows that SIM enhances learning when it aligns with learning objectives, has a clear structure and organisation, includes engaging multimedia, prioritises accessibility and user-friendly design, and includes assessment and feedback (Castro-Alonso et al., 2021; Johnson & Matthews, 2020).

The study identifies dependent learning as the second phase of peer instruction taking place in the class to advance Technical Drawing (TD) knowledge. Specifically, the study found project-based learning methods, peer-assisted learning, and optimizing group size in peer instruction classes suitable for dependent learning to advanced TD knowledge. In line with these findings, existing studies show that Project-based learning (PBL) facilitates the acquisition of practical and technical skills, as students engage in hands-on projects, applying theoretical concepts to real-world scenarios (dos Santos et al., 2018; Sharma et al., 2020). Similar research reveal that peer-assisted learning in technical drawing enhances comprehension, motivation, and practical application, contributing to holistic knowledge advancement (Jdia, 2021; Núñez-Andrés et al., 2022; Ryan, 2014). Furthermore, researches show that optimising group size significantly improves collaboration efficiency, individual engagement, project management, discussion dynamics, and teaching best practices needed to advance TD knowledge (Kozlowski & Ilgen, 2006; Speranza et al., 2017). Elements identified in the above studies collectively contribute to a comprehensive peer instruction strategy for advancing technical drawing knowledge.

Finally, this study identifies evaluation involving pre-class readiness assessment, peer interaction observation, conceptual understanding checks, and practical problem-solving tasks as measures for understanding students' strengths and weaknesses. Pre-class readiness assessments enhance student learning outcomes (Winarso, 2016). These assessments allow instructors to gauge students' preparedness before a class, enabling them to tailor their teaching strategies to address specific areas of weakness (Ge et al., 2022). Similarly, observing peer interactions in technical drawing learning environments positively impacts students learning (Xu et al., 2023). It fosters collaborative learning, allowing students to share insights, techniques, and problem-solving approaches (Sanchez et al., 2020). Also, incorporating conceptual understanding checks in technical drawing significantly enhances higher-order thinking skills (Heron & Palfreyman, 2023). These checks prompt students to synthesize and apply concepts, fostering a deeper understanding and encouraging the development of analytical and creative problem-solving abilities (Anggraini et al., 2019).

6. Conclusion

In the quest to enhance technical drawing teaching in Nigerian Universities, our research focused on developing a robust Peer Instruction Framework that incorporates various elements crucial for effective instruction. The study identified pre-instructional planning, independent learning for basic technical drawing skills, dependent learning for advanced technical drawing skills, and evaluation as key components of this innovative framework (See details in Figure 1 below).

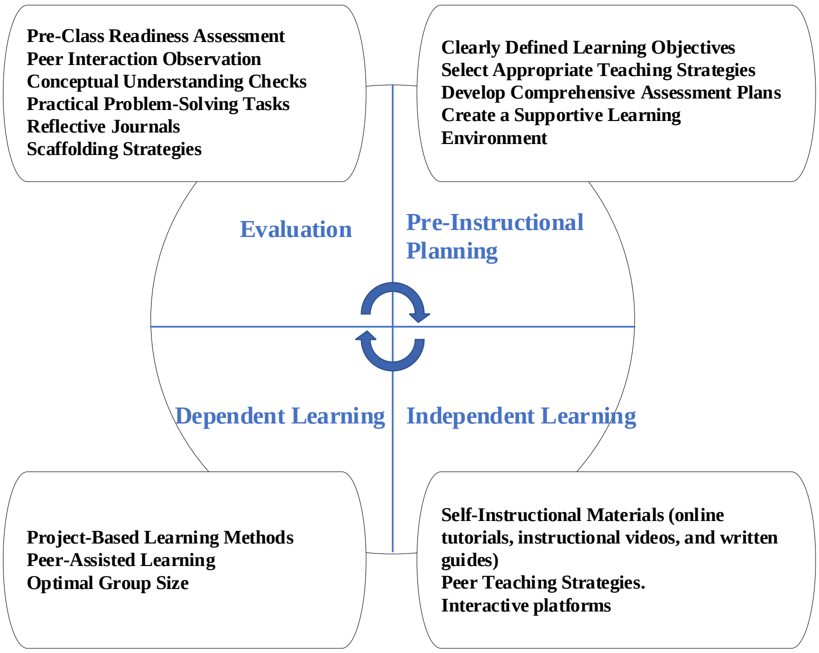

Figure 1: Proposed Peer Instruction Framework for Technical Drawing Teaching at Nigerian Universities

In this research, pre-instructional planning plays a pivotal role as the foundation of the meticulous planning phase within the Peer Instruction Framework. Specific learning objectives were clearly defined, guiding educators in shaping the course content and ensuring a targeted approach to teaching technical drawing. Furthermore, the research emphasized the importance of selecting appropriate instructional strategies during pre-instructional planning. This involves aligning the chosen methods with the predefined learning objectives to optimize the teaching-learning process.

Similarly, our findings underscore the significance of empowering students through independent learning. Online tutorials, instructional videos, written guides, peer teaching methods, and interactive platforms emerged as essential tools for fostering self-directed learning. These elements not only provide students with the flexibility to pace their learning but also encourage them to take ownership of acquiring foundational technical drawing skills.

Also, to elevate technical drawing skills to an advanced level, the Peer Instruction Framework incorporates elements of dependent learning. Project-based learning methods, peer-assisted learning, and optimizing group size were identified as effective strategies within the peer instruction classes. These collaborative approaches create an environment where students can draw on each other's expertise, fostering a deeper understanding of complex technical drawing concepts.

Finally, the assessment component of the Peer Instruction Framework is multifaceted. Pre-class readiness assessments, peer interaction observations, conceptual understanding checks, and practical problem-solving tasks serve as crucial elements in evaluating both the effectiveness of the instruction and the student's mastery of technical drawing skills. This holistic evaluation approach ensures a comprehensive understanding of the learning outcomes.

Recommendations for Further Study:

While our research provides a foundational Peer Instruction Framework, further studies could explore the implementation of this framework in diverse educational settings. Comparative studies across different Nigerian Universities or even international institutions could provide insights into the adaptability and effectiveness of the framework in various contexts. Additionally, investigating the long-term impact of the Peer Instruction Framework on students' retention of technical drawing skills and their application in real-world scenarios would contribute valuable insights for continuous improvement.

In conclusion, establishing a Peer Instruction Framework for teaching technical drawing in Nigerian Universities is a vital step toward enhancing the quality of technology-based education. By integrating pre-instructional planning, independent and dependent learning strategies, and a robust evaluation system, educators can create a dynamic and engaging learning environment that fosters technical drawing proficiency among students.

Co-Authors Contributions

Author 1: Conceptualization, manuscript writing, data collection, analysis, and interpretation. Author 2: Methodology writing/review, final manuscript approval. Author 3: Data collection, literature writing. Author 4: Data collection, literature writing.

Funding

The researchers express gratitude to the Nigerian Tertiary Education Trust Fund for sponsoring the study that led to this research. Additionally, appreciation is extended to the Department of Technical and Engineering Education at Universiti Teknologi Malaysia for their valuable assistance in completing this research.

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