

# INTEGRATION FACTORS OF 21<sup>ST</sup>-CENTURY TECHNICAL DRAWING SKILLS INTO PEER INSTRUCTION AT NIGERIAN COLLEGE OF EDUCATION

By

**BASHIRU MUSA SA'ID**

Department of Education

Waziri Umaru Federal Polytechnic Birnin Kebbi Kebbi state.

## **Abstract**

Technical drawing (TD) is a universal language for engineers, technologists, and technical personnel, facilitating precise communication of design concepts and intent. Similarly, TD enhances learning and job performance within engineering and technology programs. However, the prevalence of exclusive passive teacher-centred methods in Nigerian schools poses a significant challenge to effective technical drawing instruction. Existing research recommends a shift from passive to active teaching methods to address this issue. This study aims to employ the dynamic form of peer instruction to overcome the limitations of passive approaches in technical drawing education in Nigeria. Specifically, the research seeks to identify factors related to 21st-century technical drawing skills, both hard and soft, suitable for integration into peer instruction. Through a qualitative research design, the study interviews 15 technical drawing educators (lecturers and instructors) in central Nigeria, selected through simple random sampling. The researchers adopted thematic data analysis, including transcription, coding, and content analysis, to explore and interpret the collected information. The findings reveal crucial factors, such as self-instructional materials, attributes of self-instructional materials, and literacy skills, suitable for integration into the independent learning aspect of peer instruction for basic technical drawing hard skills.

Additionally, the finding identifies factors like application, analysis, synthesis, learning, and life skills for integration into the dependent learning aspect of peer instruction for advanced technical drawing hard skills. This study represents an initial investigation, laying the groundwork for a more in-depth exploration of factors for practical integration into peer instruction for lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS). The outcomes of this research will empower educators to implement peer instruction effectively in teaching technical drawing.

**Keywords:** Technical Drawing, Passive Teacher-Centred Methods, Active Teaching Methods, 21st-Century Technical Drawing Skills, Hard Skills, Soft Skills, Independent Learning, Dependent Learning

## **1. Introduction**

Technical drawing is a cornerstone in engineering, technology, and vocational and technical education, providing a precise language for communicating design concepts and intent. Effective teaching of technical drawing is paramount for preparing students in these fields. However, the prevalent use of exclusive passive teaching methods hampers the learning outcomes in technical drawing (Carlson *et al.*, 2018; Menekse *et al.*, 2013). Research indicates that shifting from

passive to active teaching methods is imperative (Shwartz-Asher *et al.*, 2022; Onwe and Uwaleke, 2018). This study advocates for adopting peer instruction, a proven active method for enhancing conceptual learning, problem-solving, and overall learning outcomes in physics, mathematics, engineering, and technical drawing courses (Schell and Butler, 2018; Kola, 2021; Miller-Young, 2013; Ogundola, 2017). The aim is to identify factors conducive to integrating 21st-century technical drawing skills, encompassing both hard and soft skills, into peer instruction.

21st-century technical drawing skills are crucial in the modern world, playing vital roles in learning and actual drawing production (Chu *et al.*, 2016; Martinez, 2022). Acquiring both technical drawing hard skills and relevant soft skills ensures proficiency in the language of design (Cook *et al.*, 2013). This study seeks to guarantee the acquisition of lower and higher-order technical drawing skills through independent and dependent learning aspects of peer instruction. The importance of this research lies in its potential to revolutionise technical drawing instruction, aligning it with contemporary demands and ensuring students are well-equipped for the dynamic landscape of engineering and technology.

## 2. Related Works

Technical drawing skills in the 21st century involve proficiency in Computer-Aided Design (CAD), 3D modeling, and digital visualisation (Baronio *et al.*, 2016; Siminialayi and Fomsi, 2023). 21<sup>st</sup>-century skills enhance precision and efficiency in engineering design through digital tools. Similarly, proficiency in 21<sup>st</sup>-century skills facilitates collaboration and communication among interdisciplinary teams, fostering innovation (van Laar *et al.*, 2020). Also, 21<sup>st</sup>-century TD skills impact technical and vocational instructions and performance by promoting critical thinking in technical education balancing practical skills with conceptual understanding (López *et al.*, 2023). Thus, 21<sup>st</sup>-century TD skills address challenges in effective teaching and learning methodologies, emphasising the need for adaptable pedagogical approaches (Workie, 2020; López *et al.*, 2023).

In the 21st century, technical drawing skills development involves dependent and independent learning, each playing a significant roles. Independent learning, such as self-directed learning, provides foundational technical drawing skills and knowledge (van Laar *et al.*, 2020). Similarly, guidance and feedback provided in self-directed learning benefit learners and foster a supportive learning environment. Thus, independent learning allows individuals to explore technical drawing beyond formal instruction, encouraging creativity and problem-solving (Özreçberoğlu and Çağanağa, 2018; Robb, 2008). Similarly, a personalised pace in self-learning will enable learners to progress at their own pace, tailoring their technical drawing journey to individual needs and preferences (Gamage *et al.*, 2021).

Similarly, in 21st-century technical drawing skills development, dependent learning complements independent learning by fostering collaboration, essential for navigating complex technical projects and leveraging diverse expertise (van Laar *et al.*, 2020). Also, dependent learning engages students in collaborative tasks that immerse them in critical discussions, refining their analytical skills for problem-solving in technical drawing (Li *et al.*, 2018). Furthermore, dependent learning allows students to transfer the knowledge acquired

independently, enhancing the practical application of technical drawing skills (Council, 2000). Role-play, a form of dependent learning, positively correlates with developing 21st-century skills relevant to technical drawing (Chen *et al.*, 2023). Thus, dependent and independent learning contribute synergistically to holistic technical drawing skills development in the modern era.

Teaching methods emphasising dependent and independent learning play a crucial role in 21st-century technical drawing skills development. Studies affirm that combining independent and dependent education promotes comprehension of technical drawing material (Ogundola, 2017; Baronio *et al.*, 2016). Similarly, the approach allows a shift from teaching to learning, creating a student-centred environment where teachers act as guides (Abdulrahman *et al.*, 2020). Also, teaching methods catering to independent and dependent learning allow teachers to adapt their strategies to diverse learning preferences and platforms (Shwartz-Asher *et al.*, 2022). Thus, teaching methods beyond simplistic approaches are crucial for fostering early learning skills to lay the foundation for advanced technical drawing abilities (Mazur, 2014).

This study favoured Peer instruction as it leverages pre-class activities for independent learning of lower-order thinking skills (LOTS) and in-class engagement for dependent learning of higher-order thinking skills (HOTS), aligning with Bloom's Taxonomy (Mazur, 2014). Peer instruction pre-class independent learning activities focus on foundational knowledge and comprehension (lower-order thinking skills) (Chen *et al.*, 2023). In the pre-class part, students use materials to acquire a basic understanding, utilising resources and support as needed (Jensen *et al.*, 2018). Similarly, in line with Bloom's taxonomy, in-class sessions emphasise application, analysis, synthesis, and evaluation (higher-order thinking skills) (Chen *et al.*, 2023). Thus, the in-class peer interaction, discussions, and collaborative problem-solving foster more profound understanding and critical thinking. Therefore, guided by Bloom's Taxonomy, peer instruction strategically divides cognitive demands between independent pre-class learning and cooperative in-class activities, promoting a comprehensive learning experience (R. Orozco and E. Pasia, 2021).

The study strives to seamlessly integrate factors of 21<sup>st</sup>-century TD skills into both peer instruction pre-class and in-class settings, strategically aligning with Bloom's taxonomy to facilitate the acquisition of both lower-order and higher-order technical drawing skills. Also, the study identifies factors of 21st-century soft skills suitable for acquiring lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS) within the framework of peer instruction for technical drawing. Ultimately, the overarching goal is cultivating an environment that nurtures deep technical drawing learning and equips students with essential intrapersonal and interpersonal skills for holistic learning experiences.

### 3. Methodology

The research employed a qualitative approach, utilising semi-structured interviews as the primary data collection method. This approach involved technical drawing educators, encompassing both lecturers and instructors. The researchers chose semi-structured interviews as their suitability for eliciting respondents' opinions on the study's topic (Abdul Nifa, 2013). This method allowed flexibility, enabling researchers to ask questions and vary their sequence, ensuring a depth of information (Mashuri *et al.*, 2022; Almeida *et al.*, 2017).

Purposive sampling was employed to select 15 technical drawing educators from the Central Nigerian College of Education. This technique targeted competent educators with at least 15 years of experience in technical drawing instruction, ensuring a wealth of expertise (Bell and Bryman, 2007). The interview comprised two parts: Part A focused on gathering background information, while Part B involved an interview protocol to identify 21st-century technical drawing skills (both hard and soft) for integration into peer instruction.

Data collected from the interviews underwent transcription, coding, and inductive analysis. The researchers chose the qualitative content analysis method because it is a proven strategy for analysing textual data. Also, this study's qualitative data analysis involved categorising data using inductively generated categories, applied after a meticulous close reading process. The study adheres to these qualitative methodologies to comprehensively explore factors influencing 21st-century technical drawing skills in the context of peer instruction in Nigerian Colleges of Education (Ivankova *et al.*, 2006).

#### 4. Results

This study aims to thoroughly explore TD educators' opinions on factors of 21st-century TD skills (hard and soft) suitable for integration into pre- and in-class parts of PI. Specifically, the researchers engaged participants with TD teaching competence and similar characteristics in the interview sessions. The researchers organised the results into pre-class independent learning (LOTS) and in-class dependent learning (HOTS). Consequently, LOTS and HOTS in this study equip students with 21st-century TD hard skills. Likewise, 21st-century TD soft skills in this study represent intrapersonal skills that students need to effectively learn 21st-century TD hard skills in the peer instruction's pre- and in-class learning aspects.

The researchers then categorised results from respondents' interviews into the two factors of PI: pre-class independent learning (LOTS) and in-class dependent learning (HOTS), with relevant 21st-century TD soft skills supporting the two phases. The researchers actively seek respondent viewpoints on elements that foster independent and dependent learning for 21st-century skills (hard and soft) in PI pre- and in-class. To protect the identity of the 20 respondents in the study, the researcher utilised TDE1–20 as identifiers, ensuring confidentiality and anonymity in reporting findings. The researchers systematically presented the outcomes of this study in Tables 1 and 2, corresponding to the two factors involving independent and dependent learning for 21st-century TD skills (hard and soft).

##### 4.1 Independent Learning for Lower-Order Thinking Skills

The researchers collected respondents' opinions on factors of 21st-century TD skills (hard and soft) suitable for integration into PI pre-class to support independent learning to gain TD LOTS before the class. Table 1 below presents the three key themes: self-instructional materials, self-instructional material attributes, and literacy skills from thematic analysis of responses from 20 TD educators in this study. Also, Table 1 represents the 20 participants in this study with TDE1–TDE20 and Themes 1 – 3 for the three themes that emerged from thematic data analysis.

**Table 1- Pre-Class Independent Learning Factors**

	Basic 21 <sup>st</sup> -Century TD Skills
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	<b>LOTS (TD Hard Skills)</b>		<b>TD Soft Skills</b>
<b>Participants</b>	<b>Theme 1 Self-Instructional Materials (SIM)</b>	<b>Theme 2 Self-Instructional Material Attributes (SIMA)</b>	<b>Theme 3 Literacy Skills (LITS)</b>
TDE: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20	Print Materials	Clear Content Presentation	Media Literacy Skills
TDE: 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 14, 15, 16, 19, 20	Online Tutorials	Multimedia Integration	Technology Literacy Skills
TDE: 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 20	Digital Simulation Software	Practice Exercises.	Information Literacy Skills
TDE: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19	Visual References	Self-Assessment and Feedback	

Table 1 above, on theme 1 (self-instructional materials (SIM)), 18 of the 20 or 80% of technical drawing educators endorsed print materials as SIM suitable for peer instruction pre-class for independent learning to gain basic 21st-century TD skills. 75% of respondents believed online learning programs could effectively facilitate independent learning. 95% of the respondents regarded digital simulation software as an effective form of SIM in peer instruction pre-class. 85% found SIM with visual referencing effective in promoting independent learning of 21st-century technical drawing skills in the pre-class part of peer instruction at the Nigerian College of Education. These results suggest that technical drawing educators should prioritise developing or adopting relevant SIM to support independent learning of 21st-century technical drawing skills in the pre-class part of peer instruction at the Nigerian College of Education.

In theme 2, Self-instructional Material Attributes (SIMA) (Table 1), 80% of the TD educators emphasised that SIM with "clear content presentation" facilitates independent learning in PI pre-class; specifically, 75% of the 18 participants recognised that "multimedia integration" promotes independent understanding. Furthermore, a consensus among 95% of the participants indicated that "practice exercises" as a SIM attribute aids independent learning of LOTS. Additionally, 85% of the participants affirmed that "self-assessment and feedback" as a SIM attribute can boost independent practices for LOTS in PI pre-class. These findings underscore the pivotal role of SIM with relevant characteristics in fostering the independent acquisition of fundamental 21st-century TD skills in PI pre-class at the Nigerian COE.

On theme 3, literacy skills (LITS), 80% of respondents believed that media literacy skills could facilitate independent learning of basic 21st-century technical drawing skills for students in the peer instruction pre-class phase. Similarly, 75% of TD educators believed modern technology literacy skills can assist students in learning basic 21st-century TD skills in PI pre-class independently. Finally, 85% of the respondents want TD educators to promote independent learning of basic TD skills in PI pre-class by developing information literacy skills for students. These findings underscore the critical role of literacy skills, including media, technology, and information literacy, in facilitating independent learning of fundamental 21st-century technical drawing skills. These findings suggest that TD educators in Nigerian COE must prioritise building literacy skills to maximise students' benefits from independent learning.

#### **4.1 Dependent Learning for Higher-Order Thinking Skills**

The researchers collected respondents' opinions on factors of 21st-century TD skills (hard and soft) suitable for integration into PI class to support dependent acquisition of TD HOTS. Table 2 below presents the five key themes: application skills (APPS), analysis skills (ANAS), synthesis skills (SYNS), learning skills (LEAS), and life skills from thematic analysis of responses from 20 TD educators in this study. Also, Table 1 represents the 20 participants in this study with TDE1-TDE20 and Themes 1 – 5 for the five themes that emerged from thematic data analysis.

**Table 2- In-Class Dependent Learning Factors**

	<b>Advanced 21<sup>st</sup>-Century TD Skills</b>				
	<b>HOTS (TD Hard Skills)</b>			<b>TD Soft Skills</b>	
<b>Participants</b>	<b>Theme 1 Application (APPS)</b>	<b>Theme 2 Analysis Skills (ANAS)</b>	<b>Theme 3 Synthesis Skills (SYNS)</b>	<b>Theme 4 Learning Skills (LEAS)</b>	<b>Theme 5 Life Skills (LIFS)</b>
TDE: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20	Mini-lecture (direct instruction)	Positive Learning Environment	Verbal Explanation	Critical Thinking Skills	Flexibility Skills
TDE: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20	Demonstration	Clarify Learning Objectives	Peer Discussion	Critical Thinking Skills	Leadership Skills
TDE: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19	Guided practices	Implement Peer Teaching Strategies	Implement Evidence	Communication Skills	Initiative Skills
TDE: 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20	Conceptual Questions	Promote Active Participation	Adopt Pedagogical Methods	Collaboration Skills	Productivity Skills
TDE: 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	Individual Response and Feedback	Provide Constructive Feedback Mechanisms	Foster Adaptive Expertise		Social Skills

Table 2 above on theme 1 (application skills), 95% of respondents supported integrating mini-lectures for introducing relevant facts, knowledge, and skills to promote the application of knowledge and advanced TD skills during PI class. Also, 90% believed that educators demonstrating procedures and skills assisted students in acquiring application skills. Similarly, 85% desired that educators engage students in guided practices to promote application skills.

Furthermore, 90% required educators to administer conceptual questions, prompting students to apply knowledge. Finally, 95% wanted educators to ask students to individually answer concept test questions to ensure application skills in PI class. These findings underscore the importance of various instructional strategies, including mini-lectures, demonstrations, guided practices, and conceptual questions, to enhance application skills in technical drawing education during the peer instruction classroom phase in Nigerian COE.

In theme 2 (analysis skills), 95% of TD educators affirmed that fostering a positive learning environment improves students' analysis skills. Similarly, 90% believed that educators clarifying student learning objectives is critical to enhancing analysis skills. Also, 85% supported the implementation of an established peer teaching strategy as a measure to improve students' analysis skills. Furthermore, 90% of TD educators emphasised the importance of teachers promoting active participation to achieve improved analysis skills. Finally, 95% subscribed to the idea that teachers providing constructive feedback is essential for enhancing students' analysis skills. These thematic data analysis results underscore the significance of a positive learning environment, clear learning objectives, peer teaching, active participation, and constructive feedback in fostering improved analysis skills in technical drawing education.

On theme 3 (synthesis skills), 95% of TD educators believe encouraging students to verbally or graphically articulate answers during peer discussions improves synthesis skills. Also, 90% of educators affirm that encouraging peer-to-peer interaction is crucial for achieving synthesis skills. Similarly, 85% support the implementation of evidence-based strategies by educators to enhance synthesis skills in students. Furthermore, 90% advocate adopting proven pedagogical methods like peer instruction to achieve practical synthesis skills. Finally, 95% believe that fostering flexibility and adaptive expertise enables students to integrate new knowledge as needed, contributing to improved synthesis skills. These thematic data analysis results underscore the importance of verbal and graphical articulation, peer interaction, evidence-based strategies, proven pedagogical methods, and fostering flexibility in enhancing synthesis skills in technical drawing education.

On theme 4 (learning skills), 95% of TD educators believe that integrating activities promoting critical thinking improves learning skills for students. Also, 90% of educators think incorporating creative thinking activities could enhance learning skills in students. Similarly, 85% advocate for activities fostering peer-to-peer communication as effective measures for promoting learning skills. Finally, 90% of educators emphasise the importance of activities supporting collaboration as a requirement for promoting learning skills. These findings highlight the consensus among technical drawing educators on the positive impact of critical thinking activities, creative thinking activities, peer-to-peer communication, and collaboration in enhancing students' learning skills in technical drawing education.

On theme 5 (life skills), 95% of TD educators believe that training students to be flexible thinkers positively impacts life skills. Also, 90% of educators think engaging students in leadership improves life skills. Similarly, 85% advocate for activities stimulating initiative skills as effective measures for developing life skills. Furthermore, 90% recommend activities that increase the production capacity of students as effective for building life skills. Finally, 95% of teachers

subscribe to activities boosting social interaction as a measure for promoting life skills. These findings underscore the consensus among technical drawing educators on the importance of flexibility, leadership, initiative, production, and social skills in developing life skills to excel in technical drawing practices after school.

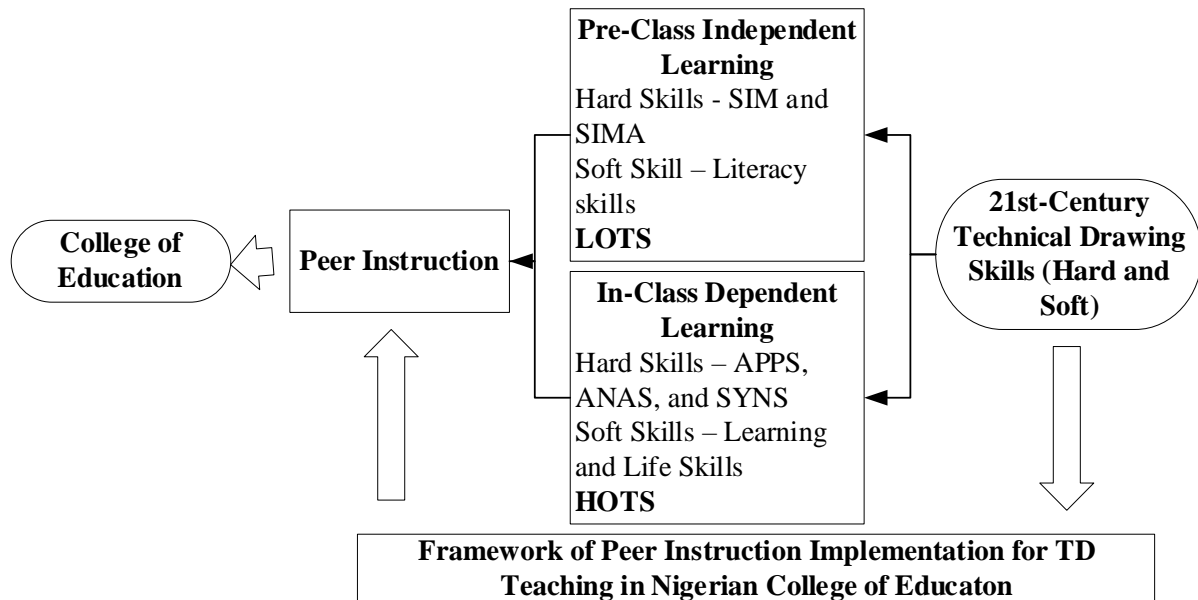


Fig. 1 - Conceptual Framework of Factors for the 21<sup>st</sup>-Century TD Skills in Peer Instruction

The above framework in Fig. 1 presents the summary of factors of 21<sup>st</sup>-century TD skills involving hard and soft elements suitable for integration into independent and dependent learning phases of peer instruction for LOTS and HOTS.

## 5. Discussion of Findings

The findings in this study emphasise integrating 21st-century technical drawing (TD) skills, comprising both hard and soft elements, into peer instruction's independent and dependent learning phases. Specifically, 21st-century TD hard skills in this study encompass lower-order thinking skills (LOTS) and higher-order thinking Skills (HOTS) as outlined in Bloom's taxonomy for cognitive learning (Sharma *et al.*, 2020). According to Mazur (2014), the pre-class phase of peer instruction facilitates independent learning to gain LOTS or basic TD hard skills, while the in-class stage supports dependent education to gain HOTS or advanced TD hard skills. Additionally, the study underscores the importance of 21st-century TD soft skills in enhancing student learning during peer instruction's pre- and in-class phases. Research indicates that cultivating soft skills, including communication, collaboration, problem-solving, and creativity in technical drawing, contributes to overall learning (Lauana *et al.*, 2022; Widodo and Wiranti, 2021). Consequently, the findings highlight the significance of nurturing hard and soft skills to deepen students' understanding of technical drawing courses (Turchyn, 2021). A balanced focus on hard and soft skills equips students with versatile competencies essential for addressing diverse challenges in the 21st century (Kim *et al.*, 2019; Fazri *et al.*, 2023).

In the pre-class phase of Peer Instruction (PI), this study emphasises the efficacy of diverse self-instructional materials (SIM) in cultivating lower-order thinking skills in technical drawing. Specifically, print materials such as textbooks and manuals, online tutorials, digital simulation software, and visual references are valuable SIMs, fostering independent learning. The research aligns with previous studies, highlighting the crucial role of varied SIMs in technical drawing (TD) education, encompassing both traditional and modern formats (dos Santos *et al.*, 2018). These materials facilitate independent learning and act as substitutes for teachers in delivering foundational knowledge during the pre-class phase of PI (Mazur, 2014). Studies indicate that instructional materials significantly contribute to an enhanced, self-directed learning experience in technical drawing, positively impacting comprehension, teacher-student interaction, and the practical application of concepts (Chedi, 2015; Owoh, 2016). These findings underscore the versatility and significance of integrating a range of SIMs to elevate the overall learning experience in technical drawing.

Regarding SIMA, this study establishes that pertinent attributes, including clear content presentation, multimedia interaction, practice exercises, self-assessment, and feedback in a SIM, facilitate independent learning for students to acquire LOTS in the PI pre-class phase. This discovery aligns with research recognising the positive impact of instructional materials with relevant attributes on the autonomous comprehension of technical drawing concepts (Owoh, 2016; Abdulrahman *et al.*, 2020). Specifically, research indicates that SIM with multimedia tools, perceptions and attitudes, drawing-to-learn intervention, and improvisation characteristics significantly improve communication, understanding, and academic achievement in technical drawing courses (McLaren, 2008; Heideman *et al.*, 2017). Additionally, concerning literacy skills, this study underscores the need to develop students' 21st-century media, technology, and information literacy skills to increase capacity for independent learning to gain LOTS in the PI pre-class phase. This integration equips students with intrapersonal skills crucial for TD LOTS acquisition independently. This finding aligns with existing research demonstrating that 21st-century literacy skills involving digital tools, fostering technological competencies, and adapting to modern educational paradigms enhance the autonomous learning experience in technical drawing (Onur and Kozikoglu, 2020; Gonzalez-perez and Ramirez-montoya, 2022). In conclusion, the study identifies SIM, SIMA, and literacy skills as critical factors for integration into the PI pre-class phase to support independent learning and help students gain fundamental 21st-century TD skills or LOTS independently.

In the class phase of Peer Instruction (PI), this study found activities aligning with HOTS of Bloom's taxonomy for cognitive learning effective for advancing 21st-century Technical Drawing (TD) skills in the dependent learning phase of PI. Specifically, this study found that the application of TD knowledge for HOTS increases for students with mini-lectures, demonstrations, guided practices, and concept tests integrated into the class part of PI. Existing studies affirm that incorporating these methods contributes significantly to a more comprehensive development of technical drawing skills within peer instruction classes (Jensen *et al.*, 2018; Zhu *et al.*, 2022; Tullis and Goldstone, 2020). Specifically, studies show that concept tests in peer instruction classes contribute to active engagement, prompt feedback, interactive learning, and optimal group dynamics, collectively enhancing the application of technical

drawing skills. Studies found that concept tests in peer instruction classes foster active engagement, prompt feedback, interactive learning, and optimal group dynamics, collectively enhancing the application of technical drawing skills (Tullis and Goldstone, 2020; Rivadeneira and Inga, 2023). Regarding analytical skills, this study found that a positive learning environment, peer teaching, constructive feedback, opportunities for peers to discuss ideas, and active learning increased analysis skills for students to gain HOTS in technical drawing. Similarly, research demonstrates that peer discussion periods in peer instruction facilitate active learning, improve conceptual understanding, and provide comparative assessment opportunities necessary for expediting the development of higher-order thinking skills in technical drawing (Knight and Brame, 2018; Schell and Butler, 2018; Zaid *et al.*, 2018).

In synthesising skills, this study underscores that verbal explanations, active peer-to-peer discussions, evidence-based strategies, and adaptive expertise collaboratively contribute to a dynamic and practical knowledge synthesis within a peer instruction class, fostering higher-order thinking Skills (HOTS) in technical drawing. Research indicates that the synthesis of knowledge during peer instruction, coupled with learning innovations and technology integration, significantly propels the advancement of higher-order thinking skills among technical drawing students (Schell and Butler, 2018; Kwangmuang *et al.*, 2021). Similarly, the study highlights the imperative for educators to integrate critical and creative thinking, collaboration, and communication learning skills into the Peer Instruction (PI) class component to foster intrapersonal skills necessary for acquiring Technical Drawing (TD) HOTS or advanced 21st-century TD skills. Studies indicate that peer instruction provides a dynamic platform for cultivating and applying the 21st-century learning skills crucial for success in technical drawing instruction (Babu Chiruguru, 2020; van Laar *et al.*, 2017). Moreover, the study emphasises the practicality of developing 21st-century life skills in aiding students to acquire TD HOTS within peer instruction classes. Research reveals that students with relevant life skills experience improvements in problem-solving, critical thinking, inclusive learning, and the development of higher-order thinking skills in technical drawing instruction (Gupta, 2021).

In summary, this study recognises self-instructional materials, attributes of such materials, and literacy skills as suitable factors for integration into the pre-class phase of peer instruction. This integration facilitates independent study to acquire lower-order thinking skills in technical drawing or foundational 21st-century technical drawing skills. Likewise, the study identifies application, analysis, synthesis, learning, and life skills as factors for integration into the peer instruction class phase. This integration supports dependent education, enabling the acquisition of higher-order thinking skills or advanced 21st-century technical drawing skills.

## 6. Conclusions and Recommendations

This study found two distinct phases of peer instruction that aligned with Bloom's taxonomy for cognitive learning, encompassing both Lower Order Thinking Skills (LOTS) and Higher Order Thinking Skills (HOTS) effective for TD instruction. These phases entail self-directed learning for LOTS in the pre-class phase of Peer Instruction (PI) and collaborative learning for HOTS during the in-class PI phase. Consequently, the study identifies LOTS and HOTS exposure in PI as a prerequisite for exposing students to relevant TD knowledge, skills and attitudes for 21st-century TD hard skills. Similarly, the research underscores the necessity of developing 21st-century soft skills, including literacy, learning, and life skills, to facilitate independent and collaborative learning for LOTS and HOTS in PI pre-and-class phases for TD courses. The study advocates for a balanced integration of LOTS, HOTS, and soft skills in PI for technical drawing instruction to guarantee a comprehensive skill set for academic success and prepare students for future professional challenges. Consequently, this study recommends integrating relevant self-instructional materials, self-instructional material attributes, and literacy skills to promote TD LOTS, essential for foundational 21st-century TD skills, during the PI pre-class phase.

Similarly, the study proposes integrating activities that promote application, analysis, synthesis, learning, and life skills into the in-class PI phase, targeting HOTS and advanced 21st-century TD skills. Ultimately, this research suggests capacity building for Technical Drawing (TD) educators in Nigerian schools to integrate 21st-century TD skills into Peer Instruction (PI), enhancing the overall quality of TD teaching.

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