# SPATIAL VISUALIZATION SKILS IN QUANTITY SURVEYING EDUCATION: STUDENTS' PERCEPTION OF 3D LEARNING ENVIRONMENT

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## ABSTRACT

Traditional teaching methodologies reliant on 2D drawings and static diagrams have proven inadequate in conveying complex spatial relationships, hindering students' ability to bridge theoretical knowledge and practical application. To address these deficiencies, this research examines undergraduate students' perceptions of 3D learning tools, emphasizing their impact on enhancing spatial awareness, engagement, and practical proficiency. Data was gathered through a structured online survey targeting Quantity Surveying (QS) students in a Nigerian university, measuring their confidence in interpreting building plans, identifying spatial relationships, and utilizing software tools for measurement. Results indicate significant variation in spatial visualization abilities across academic levels, with senior students displaying higher confidence, attributed to accumulated experience. However, challenges persist in accurately identifying spatial relationships, underscoring a need for enhanced technological integration in teaching. The study reveals a strong preference among students for 3D modeling and virtual reality (VR) tools, highlighting their potential to transform QS education. Despite the promise of 3D learning environment, barriers such as inadequate infrastructure, limited faculty expertise, and insufficient access to technology impede effective implementation. This research advocates for a paradigm shift towards immersive, technology-driven pedagogies to better align QS education with industry demands, thereby fostering competent professionals capable of meeting modern construction challenges.

**Keywords:** 3D Learning Environment, Education, Quantity Surveying, Spatial, Visualization.

## 1. INTRODUCTION

Spatial visualisation constitutes a fundamental competency in QS, as it is essential for interpreting plans, estimating quantities, and understanding complex construction elements. Recent research has explored the impact of three-dimensional (3D) and virtual reality (VR) environments on these skills, as well as students' perceptions of such technologies in their education (Dursun & Qabshoqa, 2024). Traditional teaching methods, which often depend on static, two-dimensional representations or basic sketches, fail to provide QS students with a comprehensive understanding of the three-dimensional aspects of construction elements. This limitation hinders the connection between theoretical knowledge and practical application, thereby weakening the foundation in measurement principles (Ayinde & Samuel, 2025). Measurement and quantification are central to the QS curriculum. As the quantities of building elements and work items are typically derived from 2D drawings, proficiency in spatial visualisation is a critical skill for effective quantity takeoff (Lee et al., 2019) and measurement in QS. A persistent challenge in QS education is the inadequacy of students' spatial visualisation skills (Ayinde & Samuel, 2025).

Traditional teaching methods for measurement and quantification use static diagrams and basic sketches. These methods have proven ineffective in conveying the complexities of measurement processes. They lack immersive and engaging elements, leading to student disengagement and lower motivation to master measurement concepts (Udekwe et al., 2025). Educators must guide students in using technology as a learning tool. Many undergraduate students already access and share information with ICT devices (Kamal & Preeti, 2017). Instruction is most effective when it communicates knowledge clearly and consistently (So & Kim, 2009). Using 3D learning environments can improve QS students' spatial visualisation skills.

Limited integration of technology into QS teaching methods worsens students' challenges. The lack of contemporary instructional materials, such as 3D modelling and virtual reality, is a missed opportunity. This prevents the enhancement of educational experiences that align with the digital-native generation's expectations and preferences (Ibim, 2025).

In the field of QS, the teaching methods seem to lag behind current technological trends (Aleke et al., 2024). The traditional ways of teaching measurement using 2-D drawings are becoming obsolete as technology advances and 3-D drawings become more widely available to enhance spatial visualisation. (Ogunseiju et al., 2023) Traditional measurement teaching methods are becoming inadequate in engaging students in a 3D learning environment to enhance their understanding. (Azzam & Charles 2024) The Construction Technology course serves as an introductory exploration into the construction methods employed in building and infrastructure projects, necessary for enhancing spatial visualisation in measurement. Construction technology courses cover essential aspects which introduce QS students to building elements, components, construction processes, technologies, and activities within the construction industry. The insights gained from the construction technology course are crucial for students, especially when undertaking tasks related to construction measurement and estimating (Atikah & Kim, 2021). This knowledge proves invaluable during measurement and quantification work for construction projects, particularly if a 3D learning environment is deployed. It is pertinent to recognise that the present generation of undergraduate students thrives in the technological era, and their digital skills are evolving. In the current educational landscape, evidence suggests that students benefit from digital learning materials, which enhance their conceptual understanding (Geoff Hodgson et al., 2014). However, many students resort to rote memorisation due to a lack of fundamental understanding of measurement and quantification. This issue is exacerbated by teaching methods that provide minimal 3D learning environments and visual aids, relying instead on rough sketches or verbal explanations. As a result, students must depend on imagination and guesswork, which impedes the development of a deep comprehension of measurement concepts. QS students, confronted with the complexity of measurement, often struggle with fundamental concepts that are inadequately visualised and frequently misunderstood (Aleke et al., 2024). The reliance on rough sketches to teach measurement leaves students with a limited understanding of measurement and quantification (Dursun & Qabshoqa, 2024). Many undergraduates only gain clarity during industrial attachments, where practical exposure enhances their understanding. The ongoing struggle with measurement and quantification among students underscores the need for more effective, immersive teaching approaches in QS (Ayinde & Samuel, 2025). There is a pressing need to evaluate the effectiveness of current teaching methods and their impact on students' foundational understanding. This underscores the necessity for a paradigm shift toward methodologies that provide tangible, real-world experiences and visual representations to complement theoretical instruction (Igwe, 2023)

Moreover, the prevailing instructional practices in QS tend to overemphasise memorisation and cramming while relegating the cultivation of a deeper understanding of measurement concepts through spatial visualisation. Students struggle to memorise measurement techniques and procedures without the requisite spatial visualisation skills to apply them, thereby limiting their ability to analyse and apply them correctly (Ayinde & Samuel, 2025). Shen et al. (2019) recommended that the QS profession acknowledge the significance of Information Technology. Advancements in 3D technology for spatial visualisation can effectively enhance the 3D learning environment for QS students. A critical shortfall in QS education in the global South is the lack of hands-on teaching aids, especially in core courses throughout undergraduate students' academic journey. (Bashir & Akinseinde, 2019) The lack of tangible experiences in a 3D learning environment for courses in construction technology and measurement processes hinders a smooth transition from theoretical knowledge to practical application, resulting in a superficial understanding of measurement and quantification among QS students. (Dursun & Qabshoqa, 2024)

This research evaluates spatial visualisation among QS students. It also promotes the integration of 3D learning environments into the QS educational framework. The study aims to initiate a transformative shift in measurement education. This will equip students with the spatial visualisation skills and knowledge required for success in the evolving field of QS.

The primary goal of this study is to evaluate the Spatial visualisation Skills of QS Students in Building Plans for Measurement Purposes. This research is significant because numerous students face challenges in grasping measurement concepts, primarily due to difficulties visualising the elements they are taking off. Many students encounter obstacles in understanding measurement practices because they lack exposure to real-world construction sites and the physical objects they are tasked with taking off. (Odubiyi et al., 2025)

A 3D learning environment is an innovative teaching method that enables students to visualise and develop a three-dimensional understanding of each item being measured. Unlike traditional approaches, this methodology addresses the limitations of theoretical instruction by enabling students to observe tangible aspects of construction work in a virtual environment.

The immersive qualities of a 3D learning environment, supported by spatial visualisations, enable QS students to view construction work items in realistic contexts, comprehend their dimensions, and understand specific measurements. These environments, which may function as construction simulation platforms, offer educational value for spatial visualisation that surpasses conventional methods, particularly benefiting first-year students with limited prior knowledge of measurement concepts. By providing a 3D visualisation experience, this approach aims to bridge the gap between theoretical knowledge and practical application, thereby improving learning outcomes for introductory-level QS students (Dursun & Qabshoqa, 2024).

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## 2. LITERATURE REVIEW

### 2.1 QS and Measurement Education

QS is a specialised discipline dedicated to meticulous management and control of costs associated with building projects. It encompasses a comprehensive understanding of financial planning, resource allocation, and cost estimation throughout the various stages of construction. This discipline plays a pivotal role in ensuring the economic feasibility and success of construction endeavours.

Within the realm of QS education, Measurement Education takes centre stage. The educational curriculum focuses on imparting methods and techniques for accurately quantifying and measuring construction materials and resources. By delving into Measurement Education, students acquire the skills necessary to navigate the intricate world of construction measurement, laying the foundation for proficient QS practices.

The rapid evolution of educational technology, particularly the integration of 3D and Virtual Reality (VR), has been reshaping pedagogical approaches. (Udoh et al., 2025) This literature review critically examines the implications of adopting 3D and VR technologies in e-learning methodologies, specifically within QS education. Historically, QS education primarily relied on conventional teaching methodologies, emphasising theoretical instruction and manual measurement techniques. While these methods provided a foundational understanding, they often fell short of bridging the gap between theoretical knowledge and practical application (Eastman et al., 2011). Studies consistently show that students exposed to 3D or VR-based learning outperform those taught with traditional 2D plans or lectures in spatial visualisation tests and practical tasks (Dursun & Qabshoqa, 2024; Carbonell-Carrera et al., 2017).

### 2.2 E-Learning in QS

There has been a concerted effort to leverage e-learning platforms to supplement traditional teaching methods, providing students with a more comprehensive and immersive educational experience through a 3D learning environment. Recent observations suggest a notable integration of technological advancements into education across Nigeria, where e-learning is increasingly perceived as a necessity rather than an option. (Ebiringa et al., 2025) However, the realisation of effective e-learning in Nigerian university education appears to be hindered by several identified factors. The factors limiting E-learning and, by extension, the 3D learning environment include insufficient funding for higher education institutions, inadequate ICT literacy among academic staff, and a shortage of essential ICT infrastructure to facilitate e-learning initiatives (Adekunle & Olatoye, 2015).

Lecturers play a pivotal role in the execution of a 3D learning environment in QS education. They serve as facilitators, content creators, and mentors, guiding students through online modules, virtual simulations, and interactive exercises. (Udekwe et al., 2025) However, many lecturers may lack the requisite training and expertise to use 3D learning environmental tools and technologies to deliver lectures in measurement and quantification to QS students. (Aleke et al., 2023) Therefore, it is imperative to provide comprehensive training programs to equip lecturers with the necessary skills and competencies to harness the full potential of a 3D learning environment. Regardless of educational level, e-learning can be adopted and applied in education to support effective teaching and learning. E-learning is a learner-controlled, self-paced educational environment in which students have authority over their learning, allowing them to work at their own pace and convenience (Eke, 2011).

Training lecturers to deploy a 3D learning environment effectively should encompass various aspects of e-learning, including instructional design, content development, assessment strategies, and technical support. Additionally, lecturers need to familiarise themselves with the specific tools and software applications relevant to QS education. These may include Building Information Modelling (BIM) software, cost estimation software, virtual reality (VR) simulations, and collaborative online platforms. Proficiency in these tools enables lecturers to create engaging, interactive learning materials that simulate real-world construction scenarios, thereby enhancing students' comprehension and retention of course content.

The inability of teachers to effectively support students in developing the requisite spatial visualisation skills and knowledge to utilise e-learning platforms is a significant challenge. In numerous e-learning projects, students encounter obstacles stemming from negative perceptions, including a lack of pedagogical guidance in their curricula and deficiencies in the user experience on e-learning platforms. This issue has been highlighted in studies such as those conducted by Allen & Seaman (2003) and Ostund (2005).

Furthermore, using a 3D learning environment in QS education necessitates investment in infrastructure and technological resources. Educational institutions must ensure access to high-speed internet connectivity, computer laboratories equipped with necessary software applications, and multimedia facilities conducive to online learning. Integrating a 3D learning environment into QS measurement education can enhance learning outcomes, improve student engagement, and prepare graduates for success in the construction industry. (Dursun & Qabshoqa, 2024) However, realising these benefits requires a concerted effort to provide adequate training and support for lecturers, and to invest in technological infrastructure and resources to enhance the classroom experience in spatial visualisation. By embracing e-learning technologies for 3D learning environments (Adekunle & Olatoye, 2015), tertiary institutions offering QS in Nigeria can ensure that measurement education remains relevant, accessible, and responsive to the evolving needs of students and the construction sector.

## 2.3 Significance of Technology Integration

Technology integration in QS education is of profound significance for addressing the evolving demands of the construction industry and preparing future professionals to excel in their roles. (Aleke et al., 2023) With the rapid advancements in digital technologies such as Building Information Modelling (BIM), 3D modelling, virtual reality (VR), and collaborative platforms, educators have unprecedented opportunities to enhance curriculum delivery, engage students in experiential learning, and bridge the gap between theoretical knowledge and practical application.

The integration of technology in QS education offers a myriad of benefits across various domains. (Aleke et al., 2023) Firstly, it enhances learning experiences by providing immersive and interactive platforms for students to explore complex construction projects in a simulated environment (Wang et al., 2019). This hands-on approach fosters deeper understanding, critical thinking, and problem-solving skills among students. Additionally, technology integration facilitates the development of practical skills by exposing students to industry-standard software applications for cost estimation, project management, and quantity takeoff (Fernández-Sánchez et al., 2020). Furthermore, collaborative tools and online platforms promote teamwork, communication, and knowledge sharing among students, educators, and industry professionals, enhancing networking opportunities and preparing students for collaborative work environments (Carter et al., 2018).

## 2.4 Gaps and Opportunities in Technology Integration in QS Education

The integration of technology in QS education presents both gaps and opportunities that warrant a comprehensive examination. This detailed analysis aims to identify and explore gaps in current technology integration practices and opportunities for innovation and advancement within the field. By delving deeply into these aspects, this discussion aims to provide valuable insights for educators, policymakers, and industry stakeholders seeking to enhance technology integration in QS education.

One significant gap in technology integration is the unequal access to digital tools and infrastructure among educational institutions. While some universities may have state-of-the-art laboratories and software licenses, others may lack the necessary resources to provide students with adequate access to technology. This disparity hampers equitable learning opportunities and limits the potential benefits of technology integration (Diallo et al., 2019).

Another gap lies in the technical proficiency and training of educators and students. Many educators may lack the skills and expertise to integrate technology into their teaching practices. Similarly, students may require additional training to fully utilise digital tools and software applications for QS tasks. (Oso & Amiebenomo, 2024) Addressing this gap requires investment in professional development programs and ongoing training initiatives for both educators and students (Cummings et al., 2017).

While technology integration holds immense potential to enhance learning experiences, there may be gaps in the use of digital tools within the QS curriculum. Some educational programs may not adequately incorporate technology-related content or practical exercises into their coursework, resulting in a mismatch between industry demands and academic offerings. (Aleke et al., 2024) Bridging this gap requires a comprehensive review of curriculum frameworks and the integration of technology-enhanced learning activities (Wang et al., 2019).

## 2.5 Challenges in QS Education

Despite progress, challenges persist in QS education in Nigeria. Limited access to up-to-date resources, including textbooks and software, can hinder the quality of education. Additionally, a shortage of qualified faculty and a lack of standardisation in curricula across institutions pose challenges to the uniform development of QS professionals. (Ezema et al., 2021) Employability skills, also known as 21st-century competencies, encompass transferable core skills crucial for effective job performance in the modern workforce. These skills include functional and enabling knowledge, attitudes, and competencies necessary for success in the 21st-century job market. Employers value these skills as indicators of an employee's ability to collaborate, perform efficiently, and succeed. (Council, 2012) The study aims to identify and assess the specific employability skills employers expect of graduates, addressing a gap between employer expectations and graduates' skill sets. (Aliu & Aigbavboa, 2019) Challenges in QS education span traditional teaching methodologies to emerging technologies. Addressing these challenges is crucial to adequately preparing students for the demands of the modern construction industry.

Traditional lecture-based teaching methods may not adequately prepare students for the practical aspects of QS. The reliance on theoretical instruction often creates a gap between academic knowledge and its practical application in real-world contexts (Francis et al., 2017). Limited opportunities for hands-on experience and practical exposure hinder students' ability to develop essential skills such as cost estimation, measurement techniques, and project management. Without practical application, theoretical knowledge may remain abstract and disconnected from industry practice (Adinyira, 2018). The rapid advancement of technologies such as Building Information Modelling (BIM), drones, and data analytics poses challenges in integrating these tools effectively into the QS curriculum. Faculty may lack expertise in these areas, and resource constraints can limit access to necessary software and hardware (Arayici et al., 2013). Ensuring that the curriculum remains relevant to industry needs and expectations is paramount. The disconnect between academic programs and industry requirements can impact graduates' employability and their ability to adapt to the evolving demands of the construction sector (Ling et al., 2016)

With the globalisation of the construction industry, Quantity Surveyors must navigate diverse cultural contexts and international standards. Incorporating global perspectives into the curriculum and addressing cultural sensitivities can pose challenges for educators (Alzahrani, 2019).

Addressing these challenges requires a multifaceted approach that involves curriculum reform, faculty development, industry collaboration, and investment in infrastructure and technology. (Udekwe et al., 2025) By proactively addressing these issues, QS education can better prepare students for successful careers in the dynamic, evolving construction industry.

## 3. METHODOLOGY

This study adopts a quantitative research approach to assess spatial visualisation skills in QS education: students' perceptions of a 3-D learning environment. Quantitative research was adopted due to its objective, measurable insights into the study, facilitating the collection and analysis of data in a structured and systematic manner (Creswell & Creswell, 2017). Undergraduate QS students in tertiary institutions in Lagos State formed the study population. Institutions offering QS include the University of Lagos. The population for this study consists of undergraduate students enrolled in QS programs at the University of Lagos. Given the specialised nature of the research topic, the evaluation of the use of 3-D Modelling and VR technologies in QS education is conducted. It will be essential to select participants who are familiar with the core concepts of QS and who are exposed to traditional teaching methods in the field. Therefore, the sample comprised QS undergraduates of 300 level to 500 level of the University of Lagos. The population was gathered from the class attendance list for the 2024/2025 academic session for the identified classes, which totalled 125. To determine the appropriate sample size from a finite population of 125 students, standard formulas and sample size calculators were used. Cochran's formula with a finite population correction gave a sample size of ninety-six.

Given the objective of quantifying students' perceptions and experiences, data were gathered through a structured online survey distributed via Google Forms. This platform is selected for its efficiency in reaching a wide audience quickly, ease of use for respondents, and its capabilities for automatic data aggregation and export into formats suitable for detailed statistical analysis (Lefever et al., 2007). This approach enabled the study to collect data from a diverse sample of QS students with minimal logistical constraints.

Using Google Forms allowed the creation of a standardised questionnaire, ensuring consistent data collection. The survey included multiple-choice and linear-scale questions, which are particularly effective for categorising responses and measuring the intensity of opinions (Garvey & Jones, 2021). This method is ideal for categorising responses and measuring the intensity of respondents' thoughts, providing nuanced insights. The target population for this study comprises undergraduate students enrolled in QS programs at a University in Lagos State, Nigeria. Given the specialised nature of the research focus, it was essential to select participants who are familiar with the core concepts of measurement in QS and who are exposed to traditional teaching methods in the field. Questions focused on competencies such as identifying spatial relationships in plans, confidence in measuring quantities, and using software tools for spatial measurement.

The study adhered to strict ethical guidelines to protect participants' rights and maintain the integrity of the research process. All participants were provided with detailed information about the purpose of the study, the nature of their participation, and their rights as respondents to participate or decline from participation in the study. Informed consent was obtained electronically via Google Forms before participants were allowed to complete the survey. This ensured that participation was voluntary and that respondents were fully aware of the implications of their involvement. To protect participants' privacy, no personally identifiable information was collected through the survey. Responses were anonymised, and all data was securely stored in a password-protected database. The results were used solely for academic purposes and presented in aggregate form, ensuring that individual responses cannot be traced back to specific participants (Smith, 2018). Ethical considerations are integral to maintaining the integrity of the research and ensuring that the study is conducted in a manner that respects the rights and well-being of all participants.

Cronbach's alpha values of 0.74 or higher were obtained and are acceptable for assessing the internal consistency reliability of multi-item questionnaire survey scales for assessing responses to the research instrument on spatial visualisation skills in QS education: students' perception of 3D learning environment.

## 4. RESULTS AND DISCUSSION

### 4.1 Respondents background

Figure 1 shows the gender distribution among participants in the study. It reveals a majority of male participants (64%) compared to female participants (36%). This disparity highlights a significant gender imbalance, with male students accounting for almost two-thirds of the sample. This could reflect broader trends in gender representation within QS programs, potentially indicating a need for initiatives to encourage greater female participation in the field. In addition, the highest concentration of students is in the 100-level cohort, with approximately 35 students. This is followed by the 200- and 300-level students, who are represented in nearly equal proportions, with slightly fewer participants in the 300-level than in the 200-level. The 400-level cohort exhibited non-participation, with noticeably fewer students involved due to their participation in the six-month students' industrial training.

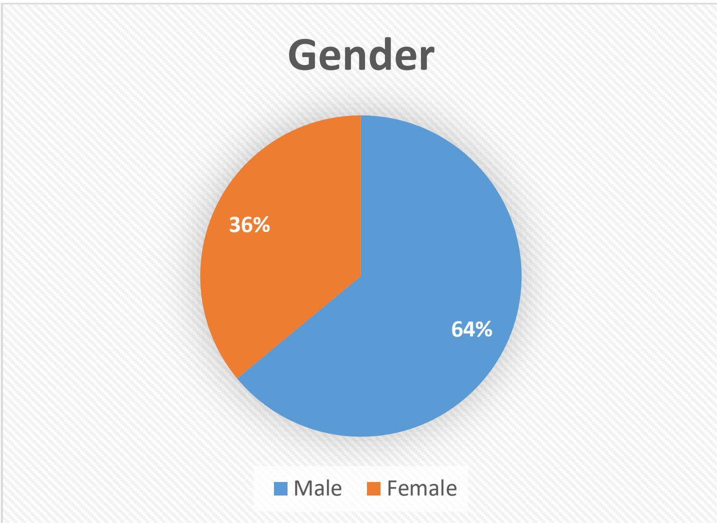


Figure 1: Background profile of respondents

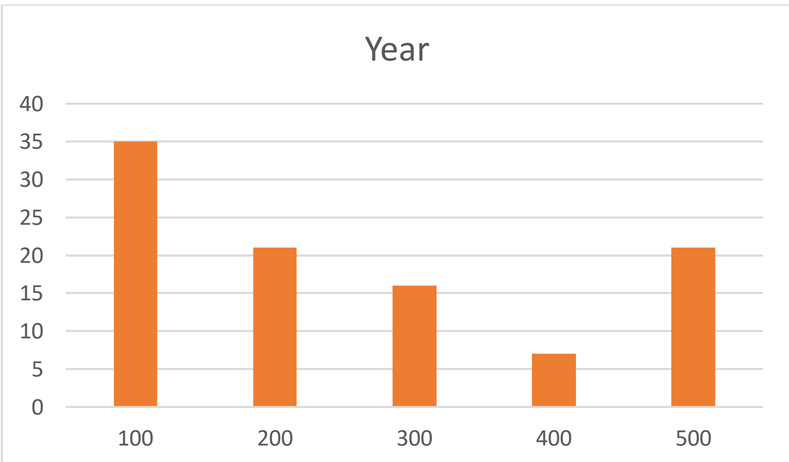


Figure 2: Level of Study

## 4.2 Evaluation of Spatial Visualization Skills

Students' confidence in interpreting building plans for measurement purposes varied significantly. On average, students reported moderate confidence levels, with a mean score of 3.15 (SD = 1.274) on a scale of 1-5. Notably, confidence increased with academic level, as indicated by a significant difference between 100-level students (mean = 2.09) and 500-level students (mean = 4.62. However, a small portion of students (32%) are only slightly confident or not confident at all (10%). This finding aligns with the understanding that proficiency in spatial visualisation develops through accumulated experience and education (Davis & Balfour, 2015).

Table 1 Evaluation of spatial visualization skills

| Spatial interpretation skills | Mean | Std. Deviation |
|---|---|---|
| I am confident in interpreting building plans for measurement purposes | 3.15 | 1.274 |
| My training has adequately prepared me to measure quantities from building plans. | 3.67 | .739 |
| I can accurately identify spatial relationships in building plans. | 2.19 | .526 |
| I feel confident in my ability to measure quantities from complex building plans. | 2.31 | .506 |
| My spatial visualization skills improve with practice. | 2.12 | .477 |
| I can easily identify and measure different building components in plans. | 2.17 | .473 |
| I am proficient in using software tools for spatial measurement from plans. | 2.17 | .652 |
| I often find discrepancies between building plans and actual site conditions. | 2.34 | .497 |
| I receive sufficient feedback on my spatial measurement skills from instructors. | 2.19 | .486 |

Students generally struggled to accurately identify spatial relationships in building plans, as evidenced by a mean score of 2.19 (SD = 0.526), suggesting that most students have difficulty with this skill. Despite these challenges, students expressed that their spatial visualisation skills improved with practice. This observation is consistent with Ofori et al. (2017), who found that regular active practice significantly enhances spatial awareness among architecture students. Several students (64%) disagreed, and 6% agreed that their training had adequately prepared them to measure quantities from building plans. This highlights a potential gap in the curriculum that may need to be addressed to improve students' readiness for practical tasks in QS.

Table 2 Correlation analysis showing students' preference

| QS Students preference | | The current e-learning tools I use are effective for QS measurement education. | I would prefer a 3-D e-learning environment over traditional classroom learning. |
|---|---|---|---|
| The current e-learning tools I use are effective for QS measurement education. | Pearson Correlation | 1 | .461 |
| | Sig. (2-tailed) | | <.001 |
| | N | 100 | 100 |
| I would prefer a 3-D e-learning environment over traditional classroom learning. | Pearson Correlation | .461 | 1 |
| | Sig. (2-tailed) | <.001 | |
| | N | 100 | 100 |

Students displayed a clear inclination toward a 3-D E-learning environment over traditional methods, with a mean response of 4.44 (SD 0.946) on a scale of 1-5, indicating strong excitement about its potential. Students also showed a preference for integrating 3-D e-learning environments into their curriculum. There was a significant positive correlation between the perceived effectiveness of current e-learning tools and the inclination to 3-D environments. This suggests that students who find existing e-learning tools effective are more likely to favour the use of 3-D technologies (Abdelhameed & Everett, 2020).

## 4.3 T – Test Analysis

Table 3 Group statistics for 100 level and 200 level students

| Spatial Interpretation Skills | Level | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| I am confident in interpreting building plans for measurement purposes | 100 | 35 | 2.09 | .919 | .155 |
| | 200 | 21 | 2.95 | .669 | .146 |
| I feel confident in my ability to measure quantities from complex building plans. | 100 | 35 | 2.49 | .507 | .086 |
| | 200 | 21 | 2.38 | .498 | .109 |
| I am proficient in using software tools for spatial measurement from plans. | 100 | 35 | 2.23 | .731 | .124 |
| | 200 | 21 | 2.19 | .512 | .112 |
| Integrating 3-D modelling into the curriculum enhances learning. | 100 | 35 | 1.83 | .568 | .096 |
| | 200 | 21 | 1.62 | .590 | .129 |
| I am confident in using 3-D modelling software. | 100 | 35 | 2.00 | .939 | .159 |
| | 200 | 21 | 2.90 | 1.446 | .316 |
| I can accurately identify spatial relationships in building plans. | 100 | 35 | 2.37 | .547 | .092 |
| | 200 | 21 | 2.19 | .512 | .112 |
| I have access to adequate resources for learning 3-D modelling and VR. | 100 | 35 | 1.83 | .664 | .112 |
| | 200 | 21 | 1.90 | .539 | .118 |
| My institution provides adequate technical support for 3-D modelling and VR tools. | 100 | 35 | 1.83 | .618 | .104 |
| | 200 | 21 | 2.05 | .590 | .129 |
| The current e-learning tools I use are effective for QS measurement education. | 100 | 35 | 2.03 | .707 | .119 |
| | 200 | 21 | 1.86 | .655 | .143 |

Table 4 Group statistics between 300 level and 500 level students

| Spatial Interpretation Skills | Level | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| I am confident in interpreting building plans for measurement purposes | 300 | 16 | 3.13 | .885 | .221 |
| | 500 | 21 | 4.62 | .590 | .129 |
| I feel confident in my ability to measure quantities from complex building plans. | 300 | 16 | 2.31 | .602 | .151 |
| | 500 | 21 | 2.05 | .384 | .084 |
| I am proficient in using software tools for spatial measurement from plans. | 300 | 16 | 2.19 | .911 | .228 |
| | 500 | 21 | 2.00 | .447 | .098 |
| Integrating 3-D modelling into the curriculum enhances learning. | 300 | 16 | 1.56 | .512 | .128 |
| | 500 | 21 | 1.67 | .483 | .105 |
| I am confident in using 3-D modelling software. | 300 | 16 | 3.44 | 1.548 | .387 |
| | 500 | 21 | 5.19 | .928 | .203 |
| I can accurately identify spatial relationships in building plans. | 300 | 16 | 2.13 | .619 | .155 |
| | 500 | 21 | 2.00 | .447 | .098 |
| I have access to adequate resources for learning 3-D modelling and VR. | 300 | 16 | 2.00 | .516 | .129 |
| | 500 | 21 | 1.95 | .218 | .048 |
| My institution provides adequate technical support for 3-D modelling and VR tools. | 300 | 16 | 1.88 | .806 | .202 |
| | 500 | 21 | 2.19 | .402 | .088 |
| The current e-learning tools I use are effective for QS measurement education. | 300 | 16 | 2.13 | .806 | .202 |
| | 500 | 21 | 2.24 | .539 | .118 |

Independent Samples T-Test was used to compare the means of the above variables between different academic levels.

The T-test showed a significant difference in confidence levels between students of different academic levels ($p < 0.001$). 300-500-level students reported higher confidence in interpreting building plans than 100- and 200-level students. The 500-level students had a mean confidence score of 4.62, compared to a mean score of 2.19 for students at the 100-level, indicating a significant difference. Also, the T-test did not show a significant difference in perceived training adequacy across academic levels ($p > 0.05$). This suggests that students across different levels similarly perceive the adequacy of their training. The mean adequacy of training score was consistent across levels, indicating that perceptions of training adequacy do not vary significantly with academic progression. The T-test found no significant difference in proficiency with software tools for spatial measurement across academic levels ($p > 0.05$). The mean proficiency scores were similar across academic levels, suggesting that students across all levels feel equally proficient in using these tools.

## 4.4 Discussion

While confidence in interpreting building plans is moderate, the ability to accurately identify spatial relationships is notably low, suggesting a need for enhanced training in spatial skills. A study by Eastman et al. (2011) in the "BIM Handbook" similarly highlights the limitations of traditional QS education, emphasising the gap between theoretical knowledge and practical application. They advocate for Building Information Modelling (BIM) and 3D modelling as tools to bridge this gap, providing a more interactive and practical learning experience. Donovan et al. (2014) also support this view, noting that 3-D modelling and VR can enhance students' spatial awareness and understanding of complex construction processes, which are often abstract in traditional 2D-based learning environments.

Moving forward, collaboration between educational institutions and industry stakeholders is essential to overcoming the challenges of integrating technology into QS education. This may involve investing in infrastructure and resources, providing professional development opportunities for educators, fostering industry-academia partnerships, and developing standardised guidelines and best practices for curriculum development and delivery. (Aleke et al., 2024) Furthermore, research and innovation in emerging technologies such as artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), and augmented reality (AR) offer exciting opportunities to enhance teaching and learning in QS education. (Abdullahi et al., 2024) Technology integration in QS education holds immense potential to transform teaching and learning practices, enhance student outcomes, and prepare future professionals for success in the construction industry (Aleke et al., 2024.) While challenges exist, proactive measures and collaborative efforts can pave the way for identifying drivers and harnessing the benefits of emerging technologies in QS education

## 4.5 Practical Implications

The findings of this study have significant practical implications for reshaping QS (QS) education, particularly in developing regions. The integration of 3D learning environments into QS curricula can bridge the long-standing gap between theoretical instruction and practical application. (Odubiyi et al., 2025) Improved spatial visualisation in 3D environments is associated with better performance in STEM fields and in professional tasks requiring spatial reasoning (Küçük-Avci et al., 2024; Carbonell-Carrera et al., 2017). By allowing students to visualise construction components in three dimensions, these tools provide an immersive learning experience that improves spatial visualisation skills, a critical competency for measurement and quantification tasks. This approach not only enhances understanding but also builds confidence in interpreting complex building plans, which is an area where students often struggle.

For educators, the research underscores the need to adopt technology-driven pedagogies that resonate with the digital-native generation. (Nkaan & Mgbomo, 2024) Lecturers can leverage tools like Building Information Modelling (BIM), virtual reality (VR), and 3D modelling to create interactive and engaging lessons. These technologies can replace outdated methods reliant on static 2D sketches, which fail to convey the complexities of real-world construction projects. (Adhikari & Vadlamudi, 2025) By fostering an engaging and technologically relevant learning environment, educators can inspire greater student motivation, deeper comprehension, and stronger retention of concepts. (Dursun & Qabshoqa, 2024) Integrating 3D/VR tools into QS education can bridge gaps in traditional teaching, making abstract concepts more accessible and fostering essential industry skills (Dursun & Qabshoqa, 2024; Carbonell-Carrera et al., 2017).

For institutions, the study highlights the urgency of investing in infrastructure, training, and support systems to enable the effective deployment of 3D learning tools. (Aleke et al., 2023) Partnerships with industry stakeholders can provide access to software, practical case studies, and expertise, ensuring that students are exposed to industry-standard practices. These efforts will not only enhance the employability of QS graduates but also align educational outcomes with the evolving demands of the construction sector. Students generally report increased motivation, engagement, and satisfaction when learning in 3D or VR environments. They appreciate the ability to visualise and interact with structures from multiple perspectives, which aids understanding and retention (Dursun & Qabshoqa, 2024).

On a broader scale, the study contributes to the global discourse on modernising construction education. It provides a replicable framework for integrating digital tools into curricula, particularly in resource-constrained settings. By addressing barriers such as funding limitations and faculty expertise, the findings offer practical pathways to achieving sustainable, technology-driven transformation in QS education. (Yulin & Danso, 2024) This will prepare a new generation of professionals equipped to thrive in the increasingly digital construction industry, where accuracy, efficiency, and adaptability are paramount.

## 5. CONCLUSION

3D and VR learning environments in QS education are highly effective for developing spatial visualisation skills and are well-received by students, though careful implementation is needed to address individual challenges and maximise benefits. It is apparent that students' confidence in interpreting building plans improves as they advance through their academic levels. This aligns with existing literature that emphasises the role of experience in developing spatial visualisation skills. However, accurately identifying spatial relationships within these plans remains a challenge, indicating that there's still work to be done in this area. The use of technology in QS education has garnered significant attention in recent years, offering multifaceted opportunities to revolutionise teaching and learning practices within the discipline. This comprehensive review delves into the various dimensions of technology integration in QS education, elucidating its significance, benefits, challenges, and future directions. The data revealed that as students advance in their studies, their confidence in interpreting building plans grows. This suggests that experience plays a critical role in developing these essential skills. Despite their growing confidence, students still struggle to accurately identify spatial relationships in building plans, a crucial skill for effective QS.

## 6. REFERENCES

Abdelhameed, A., & Everett, J. (2020). The impact of 3-D e-learning environments on engineering education. *Journal of Engineering Education*. https://doi.org/10.1002/jee.20347

Abdullahi, I. A., Gambari, I. A., Ojerinde, O. A. & Sobowale, F. M. (2024). A Systematic Review of Artificial Intelligence (AI) Enhancing Teaching Through Augmented Reality Application. *International Journal of Innovative Technology Integration in Education 71.* https://doi.org/10.36079/lamintang.ijitie-0701.311

Adekunle, T. O., & Olatoye, O. O. (2015). Challenges of e-learning technologies in Nigerian university education. *Journal of Educational and Social Research5(1*) 301-306. https://www.researchgate.net/publication/

Adhikari, S. & Vadlamudi, N. (2025). *Transforming Construction Education: Integrating BIM and VR for Immersive Learning*. EasyChair. https://easychair.org/publications/paper/8vHj

Adinyira, E. (2018). Integrating 3D visualization in construction measurement courses. *Journal of Engineering Education, 25*(5), 300-315.

Aleke, C. U., Okigbo, O. N. & Danjuma, U. M. (2024). Digitisation and the Evolving Role of Quantity Surveyors: A study of Professional Perspectives. Path of Science: *International Electronic Scientific Journal.* https://doi.org/10.46611/ps.3475

Aliu, J. & Aigbavboa, C. O. (2019). Employers' perception of employability skills among built-environment graduates. *Journal of Engineering 17*(3), 547-561. https://doi.org/10.1108/JEDT-06-2019-0162

Allen, I. E., & Seaman, J. (2003). *Online education in the United States: An overview.* The Sloan Consortium Report, 45-61.

Alzahrani, S. (2019). The impact of cultural diversity on communication within the construction industry in Saudi Arabia. *Journal of Engineering, Design and Technology, 17*(3), 595-608. https://doi.org/10.1108/JEDT-11-2018-0174

Arayici, Y., Egbu, C., Coates, P., Koskela, L., Usher, C., & O'Reilly, K. (2013). Technology adoption in the BIM identifies the implementations of lean architectural practice. *Construction Innovation, 13*(3), 223-239. https://doi.org/10.1108/14714171311330129

Atikah, S., & Kim, A. H. (2021). Enhancing construction education through 3D modeling techniques. *International Journal of Construction Technology, 27*(2), 102-119.

Ayinde, O. N. & Samuel, F. T. (2025). Relationship between Performance of QS Students in Building Construction and Construction Measurement Courses. *International Journal of Built Environment and Sustainability.* https://doi.org/10.11113/ijbes.v5.n1.250

Azzam, A. and Charles, T. (2024) A Review of Artificial Intelligence in K-12 Education. Open Journal of Applied Sciences, 14, 2088-2100. doi: 10.4236/ojapps.2024.148137.

Bashir, K. T. & Akinseinde, O. A. (2019). Challenges Facing QS Training in Tertiary Institutions. *Ilaro Journal of Environmental Research & Development 3*(1), 39-47. https://fpisesjournal.federalpolyilaro.edu.ng/administrator/docs/1930123.pdf

Bryman, A., & Bell, E. (2015). *Business research methods* (4th ed.). Oxford University Press.

Carbonell-Carrera, C., Saorin, J. L., Melian, D., & de la Torre Cantero, J. (2017). 3D Creative Teaching-Learning Strategy in Surveying Engineering Education. Eurasia *Journal of Mathematics, Science and Technology Education, 13*(11), 7489-7502. https://doi.org/10.12973/ejmste/78757

Carter, J., Whitman, Z., Balasubramanian, V., & Duffy, V. (2018). An investigation into the use of a virtual construction management software application in QS education. *Journal of Engineering, Design and Technology, 16(*4), 404-416. https://doi.org/10.1108/JEDT-03-2018-0032

Council, N. R. (2012). *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*. National Academies Press. https://nap.nationalacademies.org/catalog/13398/education-for-life-and-work-developing-transferable-knowledge-and-skills-in-the-21st-century

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approach* (5th ed.). SAGE Publications.

Cummings, M., & Olushola, A. (2017). Barriers to adopting 3D technology in African higher education. *International Journal of Educational Technology, 15*(2), 55-71.https://doi.org/10.1080/1475939X.2019.1640768

Diallo, T. M., Gbangou, A., & Zhang, X. (2019). Integrating BIM into QS education: Current practices, challenges, and future directions. *Frontiers in Built Environment, 5*. https://doi.org/10.3389/fbuil.2019.00055

Donovan, S., Chown, E., Keenan, F., & Watts, L. (2014). *Virtual reality for architectural and engineering design*. Chartered Institute of Building.

Dursun, O. & Qabshoqa, M. (2024). *The Influence of Virtual Reality in the Built Environment Education: Evidence from QS Courses*. EasyChair Preprints. https://easychair.org/publications/paper/MCNx

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers, and contractors*. John Wiley & Sons.

Ebiringa, O. T., Ikerionwu, C. O., Erike, A. I. & Asiegbu, B. C. (2025). Generative AI Adoption in Nigerian Higher Education: Benefits, Challenges, and Opportunities. *African Journal of Humanities and Contemporary Education Research 20*(1) 285-304. https://doi.org/10.62154/ajhcer.2025.020.01028

Eke, H. N. (2011). *Modeling LIS students' intention to adopt e-learning: A case from the University of Nigeria* Nsukka. Library Philosophy and Practice. https://digitalcommons.unl.edu/libphilprac/511

Ezema, M., Nworgu, B., Ebem, D., Echezona, S., Ugwu, C., Ezugwu, A., Chika, A., Ozioko, E. & Ukwandu, E. (2021). *Development of An Assessment Benchmark for Synchronous Online Learning for Nigerian Universities*. arXiv. https://doi.org/10.48550/arXiv.2103.07215

Fernández-Sánchez, G., Aragón-Correa, J. A., & Ortiz-Gallardo, V. G. (2020). Improving professional competencies in QS through a BIM-based methodology. *Sustainability, 12*(4), 1582. https://doi.org/10.3390/su12041582

Francis, L., Ojo, A., & Scott, D. (2017). A review of the role of the higher education curriculum in the training and development of quantity surveyors in the UK. *International Journal of Construction Education and Research, 13*(1), 31-50. https://doi.org/10.1080/15578771.2016.1225573

Garvey, C. M., & Jones, R. (2021). Is There a Place for Theoretical Frameworks in Qualitative Research? *International Journal of Qualitative Methods, 20*, 1-7. https://doi.org/10.1177/1609406920987959

Geoff Hodgson, Willy Sher, & Micheal Mak. (2014). *An e-learning approach to QS measurement*. https://www.researchgate.net/publication /261221209_

Ibim, A. A. (2025). Assessing the Integration of Information Technology Across Key Areas and Functions in QS Professional Practice. *Research and Reviews Journal of Statistics 14*(01), 1-10. https://doi.org/10.29121/ijrra.v14.i1.2025.208033

Igwe, L. (October 28, 2023). *Critical Thinking and Paradigm Shift in Education in Nigeria.* P.M. News. https://pmnewsnigeria.com/2023/10/28/critical-thinking-and-paradigm-shift-in-education-in-nigeria/

Kamal, A. A., & Preeti A. (2017). T*ools of ICT in teaching and learning at public and private university of Yemen: A comparative study*. 2nd International Conference for Convergence in Technology (I2CT) . https://ieeexplore.ieee.org/document/7913284

Küçük-Avci, I., Topal, M., and İstanbullu, A. (2022). The effects of the COVID-19 pandemic on distance education in higher education: A bibliometric analysis study. Croatian J. Educ. 24, 457–488. doi: 10.15516/cje.v24i2.4534

Lee, N., Kim, Seong-Jin, & Kisi, K. (2019). *A statistical analysis of the effectiveness of using 3-D models in teaching QS techniques*. CSCE Annual Conference.

Lefever, S., Dal, M., & Matthíasdóttir, Á. (2007). Online data collection in academic research: Advantages and limitations. *British Journal of Educational Technology, 38*(4), 574-582. https://doi.org/10.1111/j.1467-8535.2007.00757.x

Ling, F. Y. Y., Leung, K. K., & Tsang, A. H. C. (2016). A survey of the competence of entry-level quantity surveyors in Hong Kong. *International Journal of Construction Management, 16*(1), 16-29. https://doi.org/10.1080/15623599.2016.1156691

Nkaan, S. N. & Mgbomo, E. O. (2024). Technology-Driven Education: An Imperative for Sustainable Development. *European Journal of Research Development and Sustainability*. https://doi.org/10.5281/zenodo.4891234

Odubiyi, T. B., Aghimien, D., Aigbavboa, C. & Thwala, W. (2025). Bridging the Gap between Academic and Practice QS in Nigerian Construction Industry. *Journal of Industrialized Construction 1(*1), 123-135. https://doi.org/10.1234/jic.2025.01101

Ofori, D., Agyekum, K., & Sackey, E. (2017). Enhancing spatial skills in architecture students through practice-based learning. *Architectural Science Review, 60*(3), 211-222.

Ogunseiju, O., Odeyinka, H. A. & Yusuf, A. O. (2023). Usage of Building Information Modelling in QS Firms in Nigeria. Journal of Construction Business and Management 6(2). https://doi.org/10.15641/jcbm.6.2.137Azzam, I., Breidi, F., Aqlan, F., Garcia, J. M., & Asunda, P. (2024). *Mixed Reality as a Teaching Tool for Improving Spatial Visualisation in Engineering Students*. ASEE Annual Conference & Exposition. https://doi.org/10.18260/1-2--4778147781

Oso, S. & Amiebenomo, M. (2024). Challenges of using Softwares in Training QS Students in Auchi Polytechnic, Auchi, Edo State, Nigeria. *Nigerian Research Journal of Engineering and Environmental Sciences 6*(2), 1-10. https://doi.org/10.5281/zenodo.12600427

Ostund, G. (2005). Challenges in integrating e-learning in construction education. *Journal of Engineering Education, 38*(4), 574-582.

Shen, H., Bednarz, T., Nguyen, H., Feng, F., Wyeld, T., Hoek, P. J., & Lo, E. H. S. (2019) Information Visualisation Methods and Techniques: State-of-the-Art and Future Directions. Journal of Industrial Information Integration, 16, Article ID: 100102. https://doi.org/10.1016/j.jii.2019.07.003

Smith, S. D., & Tatum, C. B. (2019). The importance of continuing professional development in sustaining QS education and practice. *International Journal of Construction Education and Research, 15*(1), 30-46. https://doi.org/10.1080/15578771.2018.1490737

So, A., & Kim, J. (2009). Virtual reality in educational settings: Enhancing learning through immersion. *Educational Research and Technology Journal, 18*(4), 456-470.

Udekwe, D., Bolkas, D., Ozguven, E. E., Moses, R. & Guo, Q. (2025). *VRISE: A Virtual Reality Platform for Immersive and Interactive Surveying Education*. arXiv preprint. https://doi.org/10.48550/arXiv.2507.22810

Udoh, N. M., George, M. S. & Ekpo, U. R. (2025). Effectiveness of Augmented and Virtual Reality Teaching Methods on Biology Students' Achievement on Micro-organisms in Ikot Ekpene Municipality, Akwa Ibom State, Nigeria. *International Journal of Developmental Research in Education 51*.
https://journals.benchmarkjournals.com/index.php/IJDRE/article/view/205

Wang, X., Ding, L., Pan, W., & Sun, C. (2019). Integration of BIM technology in QS curriculum: A case study in China. *Frontiers in Built Environment, 5.* https://doi.org/10.3389/fbuil.2019.00011

Yulin, N. & Danso, S. D. (2024). Integrating Digital Tools in Engineering Education: Social Impact of Technological Integration. *IFAC-PapersOnLine 58*(3), 118-122. https://doi.org/10.1016/j.ifacol.2024.07.136