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Relationship Between Students' Spatial Visualization Ability and Academic Achievement in Building Drawing, in Technical Colleges, Edo State, Nigeria

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ABSTRACT

This study investigated the relationship between students' spatial visualization ability and academic achievement in building drawings in technical colleges in Edo State. A correlational survey research design was employed for the study. The population of the study consisted of 128 vocational (1) students offering building drawing. Since the population of the study was manageable, there was no sample. 120 returned instruments which represent 93.75% of the total population were used for data analysis. Vocational (1) students were used because beginners in building drawing are expected to possess spatial visualization ability as entry behaviour into building drawing class. Statistical Package for the Social Sciences (SPSS) was employed as the statistical software for the analysis of the data.

Three research questions and null hypotheses guided the study. The two research instruments used to generate data for the study are Spatial Visualization Ability Test (SVAT), and the standardized Building Drawing Achievement Test (BDAT). SVAT was designed by the researcher and BDAT was adapted from the National Technical Certificate Examination past questions. Cronbach Alpha was used to determine the reliability coefficient of 0.85 for SVAT and 0.79 for BDAT. The hypotheses generated to achieve the purpose of the study were analyzed and tested using the Pearson Product Moment Correlation (PPMC) Coefficient. The results revealed a strongly positive relationship between students' spatial visualization ability and academic achievement, in building drawing among vocational (I) building drawing students in technical colleges in Edo State. It was also observed that male students were found to have higher scores in spatial visualization ability and building drawing than females. The researcher recommended based on the research findings among others that teachers should ensure that students develop a good spatial visualization ability before the commencement of building drawing class by providing three-dimensional solid and Computer Aided Design and Simulation of geometric and building models in the drawing studio.

Keywords: spatial visualization ability, building drawing, building construction, academic achievement.

Introduction

Technical and Vocational Education in Nigeria has a rich history, originating in the late 1960s. Technical Colleges are primarily tasked with the duty of imparting practical skills, fostering the right attitude, and instilling the necessary knowledge to cultivate proficient and well-prepared craftsmen and technicians across various technical and vocational domains. The array of trade subjects offered in Technical Colleges, particularly those pertaining to the built environment especially the construction industry, encompass welding and fabrication, mechanical engineering craft, electronic system and maintenance, refrigeration and air conditioning, bricklaying/block laying and concreting, plumbing and pipe fitting, carpentry and Joinery, building/engineering drawing, building construction, among others.

Nevertheless, Technical Colleges have encountered and continue to face a multitude of challenges, encompassing insufficient funding, outdated curricula, a shortage of qualified educators, substandard school facilities, and inadequate infrastructures.

A significant body of research spanning the annals of scientific history has delved into inquiries concerning human capacities, especially spatial abilities (which includes spatial visualization), their developmental trajectories, and the pivotal role these capacities play in diverse realms of performance. This encompasses the aptitude to forecast the altered appearance of a shape or object following cognitive manipulations and to visually depict or elucidate it in the appropriate dimensions.

It is a mental-related cognitive skill, an ability to picture or manoeuvre with the 'eye of the mind', objects or figures in two or three dimensions and bring them into reality to solve peculiar spatial problems. Spatial ability skill is referred to as a trait in human intelligence which is a vital and very

important fundamental skill in the engineering and technology field (Kok & Bayaga 2019). The utilization of visualization methods functions as a cognitive framework, supporting the integration of theoretical notions, promoting the resolution of complex problems, and augmenting communication across different academic disciplines (Billger, Thuvander & Wästberg, 2017).

Technical drawing students often exhibit proficiency in grasping theoretical concepts; however, there is a noticeable inadequacy in their capacity to effectively articulate these insights through visual representations (Wu & Rau, 2019).

This deficiency may be attributed to several factors, including lack or low level of spatial visualization ability. Spatial visualization is the ability to accurately capture a three-dimensional shape from a two-dimensional plane shape or object in space.

Spatial visualization plays a crucial role in various fields such as architecture, engineering, and design. For example, architects rely heavily on spatial visualization to conceptualize and create blueprints for buildings.

Every good building designer possesses a significant level of spatial visualization ability (SVA). Without this ability, architects may struggle to accurately translate their ideas into tangible structures.

Furthermore, in the field of engineering, spatial visualization is essential for designing complex machinery and systems. Building designers need to be able to mentally manipulate and visualize different components in three-dimensional space to ensure the functionality and efficiency of their designs.

Therefore, improving spatial visualization abilities through practice and training can significantly enhance problem-solving skills and overall cognitive abilities. By honing this skill, individual learner can become more adept at interpreting and manipulating spatial information, leading to improved performance in various academic and professional fields, especially building drawing.

A basic building drawing is an architectural drawing of simple buildings. It is simply a graphical language that refines and conveys the intent of a proposed building owner as visualized by the building designer or the architect. Building drawing is a component of technical drawing subject in science and technical colleges. It is an integral and essential component of building construction. They are initially sketched at the conceptualization stage and thereafter, transferred to measured drawing with the aid of drawing equipment or computer-aided design (CAD) software. Today, a more sophisticated digital aid, Building Information Modeling (BIM) software has made solutions to spatial problems a much easier approach, enabling designers to render and visualize construction models (VCM). Building drawing students in secondary schools like technical colleges in Nigeria are expected at the completion of the program within the limit of building drawing curriculum, to be able to understand and apply basic building technical drawing skills to solve simple spatial problems. A complete building drawing must include but not limited to a site plan, floor plan, roof plan, elevations, sections, perspectives and detailing of essential parts. The final exterior and interior forms of the building drawing if well graphically organized, represent an exact picture of the proposed building after construction.

A proficient understanding of spatial visualization is essential in the field of building construction professionals, as individuals in this technical domain often encounter intricate tasks and engage in collaborative efforts across various disciplines within the construction industry.

According to Armstrong (2015), individuals with spatial intelligence think and learn through the utilization of visual aids; possess the ability to recall faces and locations; observe intricate details that often go unnoticed by others; and establish connections between the tangible world and the imaginative realm they envision.

Spatial skills are teachable, and such teaching can provide more successful academic achievement in building technology and engineering classes.

According to Rittle-Johnson, Zippert & Boice (2018), one of the skills that significantly contributes to the enhancement of mathematical abilities in early childhood is the often underestimated spatial visualization capacity.

Lin and Chen (2016) asserted that due to the inherent complexity of spatial ability necessitating ample space and time for effective training, educational programs encounter challenges in cultivating this aptitude.

A student's cognitive capacity plays a pivotal role in foreshadowing their comprehension and, consequently, their performance in the realm of scientific disciplines (Lyna and Gavin, 2014).

Findings by Onootu, Hassan and Gana (2021) on the relationship between students' spatial ability and academic achievement revealed a strong positive relationship between spatial ability and academic achievement in physics among secondary school students (kinematics). A study by Branoff and Dobelis (2012), on the Relationship between Spatial Visualization Ability and Students' Ability to Model three-dimensional (3D) Objects from Engineering Assembly Drawings revealed a substantial correlation between students' performances on the Purdue Spatial Visualization Test: visualization of rotations (PSVT) and their results on engineering design modelling assessment. The cognitive ability of an engineer to visually conceptualize objects in three dimensions is intricately connected to their proficiency in fundamental engineering drafting subjects, (Marwa, Choji & Dalumo, 2020).

Hence, students exhibiting low academic achievement in any technical drawing course may be correlated with possessing limited spatial visualization capabilities.

The utilization of spatial visualization has the potential to empower students in interpreting two-dimensional spatial information such as building floor plan drawings.

It empowers individual learner to extrapolate this information into volumetric forms, mentally navigating through various scenarios to ascertain the accurate exterior or interior shapes of the building. Conversely, the transformation of three-dimensional models into two-dimensional is pivotal in the preliminary phases of building design and case study analysis. Mental conversion of three-dimensional building design to two-dimensional building plan involves the capacity to interpret three-dimensional volumetric data, condense intricate volumetric information, translate it into two-dimensional data, and identify the appropriate two-dimensional floor plan, as outlined by Cho and Suh (2023). Studies have indicated that the activities within current curriculum programs are insufficient in cultivating the spatial visualization ability of students. It is imperative to assess the levels of spatial visualization ability, as it can serve as a predictor for students' proficiency in architectural drawing, a domain where spatial aptitude is paramount. The deficiency in spatial visualization among high school students may stem from the inadequate instruction of these skills in classroom settings, Tarihi and Tarihi (2021).

Statement of the Problem

As the Nigerian construction industry's need for skilled professionals continues to outpace the supply, the noticeable lack of spatial visualization skills among students in Technical Colleges threatens to stifle future innovations, compromise quality, and undermine the sector's potential growth.

Despite the far-reaching implications, the relationship between students' spatial visualization ability and academic achievement in Building Drawing remains poorly understood, thereby leaving educators and policymakers bereft of a definitive road map to tackle this fundamental skill deficiency.

Subsequent reports from the National Business and Technical Examination Board (NABTEB) on students' academic achievement in building/engineering drawing has indicated low performance (Jimoh, Abd-El-Aziz & Oguche 2022).

Findings of the study by Maizam, Thomas, and David (2003), to determine if there is any relationship between Spatial Visualization Ability (SVA) and problem-solving in building structural design indicated that there is an association between SVA and problem-solving in structural design.

However, conversely, an initial study conducted by Raju, Sort, and Reid (2023) regarding the correlation between spatial aptitude and engineering drafting revealed that there existed no substantial connection between students' performance on the Midwest Flood Task and their spatial visualization abilities. However, the data analysis remains at a preliminary stage. In Nigeria communities of researchers, there are few or no studies that have been explored directly investigating the relationship between spatial visualization ability and building drawing. It is on this background the researcher takes an interest in studying the relationship between students' spatial visualization ability and academic achievement in building drawing among vocational one (1) students in technical colleges in Edo State.

Purpose of the Study

The purpose of this study was to find out the relationship between students' spatial visualization ability and academic achievement in Building Drawing among vocational one

(1) students in Technical Colleges in Edo State. Specifically, to find out the strength and direction of linear relationship between:

(2) students' spatial visualization ability and academic achievement in building drawing. 2. male students' spatial visualization ability and academic achievement in building drawing, and

3. female students' spatial visualization ability and academic achievement in building drawing.

Research Questions

The following research questions guide the study

What is the strength and direction of the relationship between:

1. students' spatial visualization ability and academic achievement in building drawing?

2. male students' spatial visualization ability and academic achievement in building drawing?

3. female students' spatial visualization ability and academic achievement in building drawing?

Research Hypotheses

The following hypotheses guided the study:

1. there is no significant relationship between students' spatial visualization ability and academic achievement in building drawing
2. there is no significant relationship between male students' spatial visualization ability and academic achievement in building drawing
3. there is no significant relationship between female students' spatial visualization ability and academic achievement in building drawing

Method of the Study

A correlational survey research design was used to achieve the specific purpose of the study. The research investigates the strength and direction of the relationship between students' spatial visualization ability and academic performance in Building drawing. The design includes collecting data to ascertain the strength and direction of the linear relationship between two quantifiable variables. (Gay, Mill & Airasian as cited in Onootu, Hassan & Gana, 2021).

Population of the Study

The population of the study consisted of the Technical Colleges in Edo State with 128 Vocational (I) students offering building drawing trade subjects. Vocational (1) students were used because beginners in building drawing are expected to posses spatial visualization ability as entry behaviour into building drawing class. 120 returned instruments which represent 93.75% of the total population consisting of 86 males and 34 females were used for the study.

Sample and Sampling Techniques

Due to the manageable size of the population, sampling was not considered necessary by the researcher.

Instrument for Data Collection

Two instruments were used for the study. Namely, the Spatial Visualization Ability Test (SVAT) and the Building Drawing Achievement Test (BDAT). The Building Drawing Achievement Test (BDAT) was adapted from NABTEB's past objective questions in the Building Drawing trade subject. Modification was carried out by the researcher to ensure that the instrument is within the scheme of work for vocational (1). The Spatial Visualization Ability Test (SVAT) was designed by the researcher to find out the level of students' visualization ability in building drawing. The instrument was a questionnaire structured into sections A, B and C. Section A deals with the personal data of the students, section B deals with objective questions on the Spatial Visualization Ability Test (SVAT) and section C deals with Building Drawing Achievement Test (BDAT) objective questions.

The SVAT contained 20 objective questions and each correct answer carried 1mark, making a total of 20 marks, while the BDAT contained 25 objective questions with each correct answer carrying 1mark, making a total of 25 marks. The instruments were administered to the respondents by trained Research Assistants in the five (5) Technical Colleges. The test scores were further converted to percentages before they were taken for analysis. The relationship between the measures in the study stated in the null hypotheses were tested using the Pearson Product Moment Correlation Coefficient (PPMC).

Validity of the Research Instruments

The two Instruments: the Building Drawing Achievement Test (BDAT) and Spatial Visualization Ability Test (SVAT) were validated by the supervisors from the Department of Vocational and Technical Education, Ambrose Alli University (AAU), Ekpoma, one from the Department of Building, Ambrose Alli University (AAU) Ekpoma, and one from Government Science and Technical College, Igarra. The corrections were effected into the final questionnaire.

Reliability of the Research Instrument

Split half reliability technique was employed to measure the internal consistency of the instruments. Copies of the instruments were administered to a group of thirty-eight (38) respondents in Vocational (1) building drawing students from Government Science Technical College, Cogo Extension, Bwari, Federal Capital Territory (FCT), Abuja. The entire 38 instruments were retrieved from the students and collated. Cronbach Alpha was employed to determine the reliability coefficients of the questionnaires which yielded values of 0.85 for SVAT and 0.82 for BDAT respectively. The population captured for the pilot study was not part of the target sample for the main study.

Method of Data Analysis

Pearson Product Moment Correlation Coefficient (PPMCC) was used to answer the research questions and the three hypotheses tested.

Results of the Study

Ho_1: There is no significant relationship between students' spatial visualization ability and academic achievement in building drawing.

Table1: Summary of Pearson Moment Correlation between Students' Spatial Visualization Ability and Academic Achievement in Building Drawing

Variables	N	Mean(x)	Std Dev.(SD)	r	P-value	Strength & Direction	Significance

SVAT	120	44.45	8.14	0.76	0.000	strong
& positive	Significant					
BDAT	120	46.03	9.33			

P < 0.05 level of significance

Table 1 above indicates the correlation between students' spatial visualization ability and academic achievement in building drawing. Students obtained SVAT mean scores of 44.45 and a standard deviation of 8.14, BDAT mean scores (x)=46.03 and standard deviation (SD)= 9.33, while the r = 0.76. This result indicated that there is a significant relationship between Spatial Visualization Ability and Building Drawing Achievement. Therefore, the null hypothesis 1 which states that there is no significant relationship between students' spatial visualization ability and academic achievement in building drawing is rejected.

Ho_2: There is no significant relationship between male students' spatial visualization ability and academic achievement in building drawing.

Table 2: Summary of Pearson Moment Correlation between Male Students' Spatial Visualization Ability and Academic Achievement in Building Drawing.

Variables & Direction	**N**	**Mean(x)**	**Std Dev.(SD)**	**r**	**P-value**	**Strength**	**Significance**
SVAT & positive	86	48.45	9.34	0.84	0.000	very strong	significant
BDAT	86	50.10	8.31				

P < 0.05 level of significance

Table 2 above indicates the correlation between male students' spatial visualization ability and academic achievement in building drawing. Male Students obtained SVAT mean scores of 48.45 and a standard deviation of 9.34, BDAT mean scores (x)=50.10 and standard deviation (SD)= 12.23, while the r = 0.84. This implies that there is a strong significant linear relationship between male students' spatial visualization ability and academic achievement in building drawing tested at a 0.05 level of significance. Therefore, hypothesis 2 which states that there is no significant relationship between male students' spatial visualization ability and academic achievement in building drawing is rejected.

Ho_3: there is no significant relationship between female students' spatial visualization ability and academic achievement in building drawing.

Table 3: Summary of Pearson Moment Correlation between Female Students' Spatial Visualization Ability and Academic Achievement in Building Drawing.

P < 0.05 level of significance

Variables & Direction	**N**	**Mean(x)**	**Std Dev.(SD)**	**r**	**P-value**	**Strength**	**Significance**
SVAT & positive	34	42.72	9.50	0.59	0.000	moderate	significant
BDAT	34	43.10	7.44				

Table 3 above indicates the correlation between Female students' spatial visualization ability and academic achievement in building drawing. Students obtained SVAT mean scores of 42.72 and a standard deviation (SD) of 9.50, BDAT mean scores (x)=43.10 and standard deviation (SD)= 7.44, while the r = 0.59. This implies that there is a significant relationship between female students' spatial visualization ability and academic achievement in building drawing tested at a 0.05 level of significance. Therefore, hypothesis 3 which states that there is no significant relationship between female students' spatial visualization ability and academic achievement in building drawing is rejected.

Discussion of Findings

This study investigated the relationship between students' spatial visualization ability and academic achievement in building drawing. Gender influence on this relationship was also studied. Results from Table 1 which presents an analysis of the relationship between students' spatial visualization ability and building drawing revealed that there was a statistically significant relationship between students' spatial visualization and building drawing academic achievement. This finding is supported by the study of Branoff and Dobelis (2012), who opined a positive relationship between spatial visualization and academic achievement in engineering drawing. In contrast to this finding, preliminary findings from a study by Raju, Sorby and Reid (2022), indicated that there was no significant relationship between performance in Engineering drawing and student spatial visualization skills. To establish the generality of the results in this study, further analysis was carried out between the two variables to find out the influence of gender on the relationship. Table 2 presents an analysis to ascertain if there exists a relationship between student spatial visualization ability and building drawing academic achievement, and showed that there was a positively high relationship among male students and Table 3 indicated a moderate positive relationship between female students' spatial visualization ability and academic achievement in building drawing. The strength of relationship was seen to be stronger among male students with a coefficient of correlation r = 0.84 compared to female students with a coefficient of correlation r = 0.59. The results in Table 2 and Table 3 indicated that male tends to have a higher mean score than females in SVAT. This result is in support of findings by Onootu, Hassan & Gana (2021) and David & David (2013), whose findings indicated that males have higher spatial ability than females. However, the result of this study contradicts the findings of Morris (2018), and Cilingir-Altinel (2018), who opined in their studies that there was no significant correlation between spatial visualization skills and architectural design among males and females. This, however, suggests that there could be unknown factor(s) other than spatial visualization ability that may have influenced male performance in building design in this study. Nonetheless, the results shown in this study generally imply that there's a significant positive correlation between students' spatial visualization ability and academic achievement in building drawing.

Conclusion

There has been substantial research indicating the importance of spatial visualization skills in Vocational and Technical Education, but there have been limited studies that have explored the relationship between spatial visualization skills and building drawing especially in Nigeria. The preliminary findings from this study indicate that there is a significant relationship between student spatial visualization ability and academic achievement in building drawing. However, the relationship appears to be higher among male students than female students. It is intended that through this study, understanding may be gained into how spatial visualization ability relates to building drawing among students in technical and vocational fields, especially building drawing trade subject in technical colleges.

Recommendation

The following are suggested recommendations based on the results of this study:

1. Students have different levels of spatial ability, hence, there may always be a need for some form of spatial ability class with the sole aim of improving students' entry behaviour for all students in building drawing trade subject.
2. Building drawing instructors should be cognizant of the significance of students' spatial aptitude in comprehending architectural design principles. It is imperative for educators to take into account the spatial proficiency of their students throughout the instructional process.
3. Teachers should strive to create a conducive artistic atmosphere in the studio, one that fosters the utilization of visual representations in the instruction and comprehension of architectural drawing principles.
4. Teachers must ensure that students cultivate proficient spatial visualization skills by offering opportunities for engaging with 3D solid modeling and computer-aided design, as well as simulating geometric and architectural structures within the drawing studio.
5. The expertise of a school counselor should be utilized to enlighten students on the advantages of enhanced spatial ability as a fundamental necessity for architectural drawings.
6. The enhancement of educational methodologies to cultivate the acquisition of fundamental architectural drawing skills or competencies among technical students prior to embarking on instruction in a specialized field such as architectural design is imperative.

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