



RELATIONSHIP BETWEEN SPATIAL VISUALIZATION ABILITY (SVA) AND THE QUANTIFICATION ACHIEVEMENTS: A CONCEPTUAL FRAMEWORK

Norhafizah Yusop^{a*}, Mohmad Mohd Derus^b

^{a,b}Faculty of Architecture, Planning and Surveying,
Universiti Teknologi MARA, Seri Iskandar Campus,
Seri Iskandar, 32610, Perak, Malaysia

*Corresponding author Email: *norha158@perak.uitm.edu.my

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Abstract

Spatial visualization ability (SVA) is claimed to influence students achievement in numerous technical fields. This research aims to establish a conceptual framework of a study on the significant impact of the spatial visualization ability achievement scores (independent variable) to the quantification course achievement (dependent variable) among Malaysian public university students in Quantity Surveying Programme. To form the research conceptual framework, literature review on spatial visualization ability aspects and academic achievements were broadly conducted. In this review, the independent variable consists of SVA (cognitive ability), cognitive style, learning style and teaching style while the dependent variable involves of quantification grade points, pre and post test scores which are used to measure the students quantification course proficiency.

Key Words: Spatial Visualization Ability; Quantification; Achievement.

1 Introduction

Quantification and costing of building works has been considered as one of the core subject in the syllabus of the quantity surveying programme. It is the most crucial course to be taught to the quantity surveying students for the purpose of students anticipated technical skill (Measurement of Construction Works) and knowledge requirements for quantity surveying profession and future employment in the industry (1-3). Spatial visualization ability (SVA) is claimed to effect students achievement in numerous technical fields such as engineering, chemistry, medical surgery, and computer animation (4-10).

In general, according to (11) imagination to visualize is one of the human cognitive skill to view mental images, sway, swivel, change and convert two or three dimensional visual stimuli. In everyday life situations, it has long been recognized that natural ability to visualize is crucial to several scientific and engineering activities (12). In such scenario, previous studies observed visualization as very crucial aspects in spatial ability (11, 13, 14). Basically, according to Maier (cited in (15)), there are five components of spatial skills such as spatial perception, spatial visualization, mental rotations, spatial relations and spatial orientation.

Although there are many previous literatures about spatial visualization (SVA), it is not focusing too much on the quantity surveying field. Essentially, quantity surveying profession is not specifically limited to quantifying, however, it is technical profession related to architecture that involved skill to interpret technical and engineering drawings. In order to quantify the quantities of the items shown in the drawings thoroughly, the quantity surveying scope of work requires the ability of the profession to fully understand the two dimensional (2D) drawings prepared by the architect or engineer and able to form it mentally in three dimensional (3D) view. This view is supported by (16) who writes that it is a benefit for the quantity surveyor to be able to visualize and rotate designs in 3D as they can see all the details that conventional 2D drawings unable to provide.

Previous studies have clarified the relationship between spatial visualization ability and academic achievements, however, the prior research have not specifically emphasized in the quantification

course. To be specific, the importance of the relationship between lacking necessary ability factor such as spatial visualization and students non-performance in quantification course achievements that may jeopardize the future production of good and exceptional quantity surveyor is still arguable. Therefore, to address the key factors of quantification proficiency issue, it is an urge to determine the relationship between lacking of cognitive-specific ability such as spatial visualization ability and the students achievement issue in quantification.

2 Literature Review

Apparently, a preliminary review of related data is necessary to establish the known extent of the quantification ability (essential attributes and qualities for the quantification skills) and learners achievement issue. It is important to identify the real factors which may affect students performance in quantification course. In tackling the problem, the following key terms are discussed to achieve the aforementioned goals (as shown on Figure 1 and Figure 2).

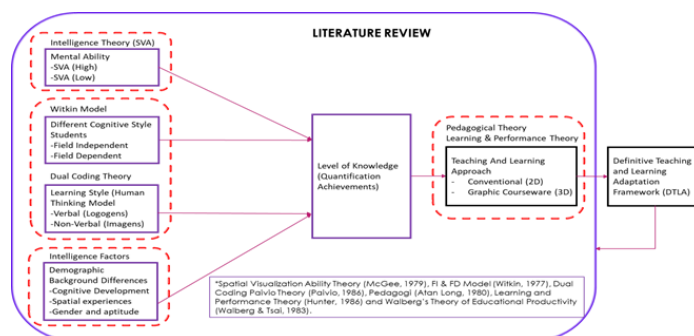


Figure 1. Research Strategy Chart

In addressing the most effective ways in teaching and learning (pedagogical) as well as to identify the research gap, Figure 1 emphasized on several factors such as relationship between the students characteristics and quantification achievement (11, 17, 18) in terms of mental ability (cognitive level), cognitive style (field independent and field dependent types), demographics background and learning style (specific teaching and learning approach).

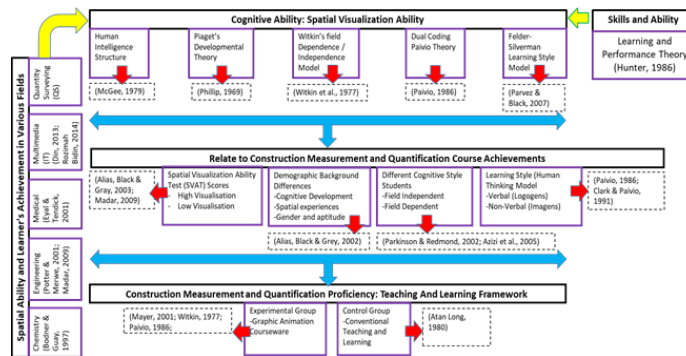


Figure 2. Breadth and Depth of Research

Furthermore, based on the previous published models and related theories(11, 18-20), Figure 2 summarizes the potential relationship between variables and the significant of the most effective learning approach to deal with variety types and characteristics of students cognitive ability differences(21), cognitive style differences (22, 23), learning style differences(24) and demographics background differences (25). At the end of the research, the research aims to propose a model known as definitive teaching and learning adaptation (DTLA) for quantification course that meet to solve current issues in terms of 1) individual ability such as students different characteristics in terms of cognitive ability, cognitive and learning styles, and 2) educational productivity and academic outcomes (identification of an effective teaching and learning approach).

2.1 Spatial Visualization Ability Versus Quantification Achievements

(26) highlights the actual indications that lead to the lacking of necessary ability factors which may affect graduates performance in quantification are still puzzling. The researcher questions whether cognitive-specific ability can be seen as a major indication of students non-performance in the quantification and whether it will affect the potential of ready-to-work graduates. Thus, to fully specify the issue, Fortune & Skilmore (1994) lists the following key questions such as 1) what are the necessary potential skill characteristics

(cognitive-specific ability) to carry out the quantification task? and 2) How are they acquired?

Recently, the quantification grade point and students achievement examination results review of one of the public university running quantity surveying courses at diploma level discovered that the students achievement were only at a satisfactory level (Academic Affair, 2016). Apparently, the beginners students were facing problems to gain understanding on the basic knowledge of construction measurement skills and cannot cope with the complex cognition process during performing the quantification task(27). This earlier finding are consistent with previous research which found that the visualization skills, one of the factors of human intelligence structure(21) are normally required through experiences and will be developed from easy to more complicated visual patterns(28).

Essentially, based on the current admission requirement, students selection criteria for public university in the quantity surveying programme only consider the following, 1) Demographic background of the candidate, 2) Examination result of the Malaysian Certificate of Education. The type of students enrolled is varied and most of them are from different academic backgrounds (Science, art students etc.). Consequently, it is very difficult for the admission committees to predict the performance of the students especially their visualization skills. A critical look at graduate admissions in some of the construction management (CM) programmes in the USA show that they usually require students to take the Graduate Record Examination (GRE) and achieve results that meet the admission requirements(29). This is a good example of the good practice as it can predict graduate performance from the early stage.

Thus, in this study, it is very important to identify the impact of the cognitive ability such as spatial visualization ability on the quantification skills among different cognitive and learning style students to be incorporated into the future decision making such as curriculum design. To improve the foundation of understanding about issues that surrounded the possible research questions, it is crucial for further related studies to explore the theories of human cognition abilities (Knowledge & Skills) of the spatial visualization ability(11, 18, 30) and other theories and predictor variables that relate with the educational productivity, learning and performance(17).

3 Methodology/Materials

The findings of this paper and the main methodology of this study were mainly through the critical literature review analysis from the local and international related educational research and existing framework. This initial study was steered to clarify the spatial ability and learners achievement issue and the crucial keywords involved before proceeding with the extension of the literature findings through questionnaires, interview and focus group pre and post test sessions.

4 Results and Findings

Table 1 summarizes the pilot articles findings of previous research in connection with cognitive ability such as spatial visualization and students academic achievement. To guide the direction of the study, the precedent from several pilot articles has been considered to mark the scope and limitation of the current study.

Table 1: Precedent Research of Spatial Visualization Ability
Framework Studies and Students Achievement

Author/Year	Issue	Aim / Objectives	Findings	Research Gap
(5)	Spatial visualization ability deficient affect students' ability in handling the complex 3D Visualization task Systematically.	Determine whether spatial ability is a significant predictor for 3D computer animation performance.	A significant relationship between spatial visualization ability and the complex 3D visualization task, computer animation course achievement.	Limited to multimedia major undergraduate students and no proposed model or framework.
(21)	Relevance of SVA to structural design problem solving achievements (association between SVA & Structural design problem solving).	Whether SVA is a key elements that may characterize the performance of civil engineering students in structural design problem solving skills.	A significant impact between spatial visualization ability and the structural design problem solving skills.	Limited to civil engineering students only: - Engineering education - Polytechnic Civil Engineering diploma programme
(12)	The impact of different media demonstrations to additive learning effects.	Implication of 2D versus 3D based media demonstrations to the spatial visualization ability of students' science major.	- Inconsistent result between the focus and treatment groups (2D & 3D). - No statistical significance was found between students' post-test score in 2D & 3D groups.	Limited to the undergraduates science major students and does not establish the connection between attitudes and performance in the spatial visualization test.
(31)	The importance of spatial thinking and visualization skills improvement in engineering education through modern technology teaching tools such as 3D CAD modelling system.	To determine whether spatial ability is an accepted predictor of success in engineering.	Visualization skills and spatial reasoning are crucial and significant relevance as a core competence determination goals of the future engineer.	Limited to engineering students only
(32)	The significant impact of CADD programs (3D) in students' spatial abilities progress development.	To determine different selected instructional methods had different effect on students' spatial abilities progress development.	A different exists in spatial ability based on the method use to instruct students using 3D CADD modelling software.	Limited to the technology discovery students.
(1)	Enhancement initiatives of current Quantity Surveyor set of skills and knowledge such as the ability to visualize, quantify, plan and schedule and manage.	To outfit the Quantity Surveyor graduates with the essential skills in project delivery through the application of Building Information modelling (BIM).	Development of BIM educational framework to meet the industry demand such as visualization, quantification, planning and scheduling and management skills.	Limited to critical literature review and development of BIM educational framework only.
(33)	The effectiveness of Bloom's Taxonomy assessment method (based on student's behaviour) in determining the education system's goal and objectives.	To review the effects of Bloom's Taxonomy to Quantity Surveying Degree programme.	The importance of Bloom's Taxonomy (cognitive) in student's academic performance and the learning objectives evaluation.	Limited to critical literature review and academicians' perspectives views only.

Having identified the outcomes and gaps from the precedent research of spatial visualization ability framework studies and students achievement, the research conceptual framework is summarized in Figure 3. The conceptual framework was designed to justify the relationship between spatial visualization ability test (SVAT) scores and the students achievement in quantification test score. Generally, to identify students specific characteristics such as cognitive ability and cognitive and learning styles, a spatial visual-

ization ability test (SVAT), group embedded figures test (GEFT), learning style and demographics background questionnaire measuring instruments will be utilized. Furthermore, for the purpose of validity testing, the final data collection stage of the research will require students to be tested with the quantification achievement test involving weak and good students from the quantity surveying programme at Malaysian public university.

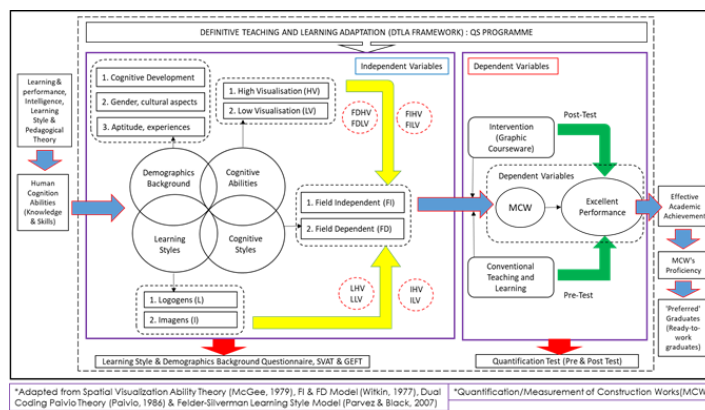


Figure 3: Research Conceptual Framework

In order to identify the relationship between students ability and styles differences with their academic achievement, the students will be asked to answer the questionnaire and several tests such as SVAT and GEFT. In addition, to examine the causal-comparative influencing factors, quasi-experimental study, $2 \times 2 \times 2$ factorial design (cognitive and learning style x students spatial visualization ability) will be done. It is very crucial to assess students knowledge, ability and styles differences from the treatment and control group test result as the findings can differentiate and categorized specific group of students in dealing with the appropriate teaching and learning strategy. Therefore, in this study, a one group for pre and post-test experimental design approach will be employed involving weak and good students that possess different level of cognitive ability, cognitive and learning styles.

Besides that, the study also will consider at the other demographics background factors influencing spatial visualization ability, cognitive and learning style such as 1) Cognitive development (subject taken at secondary school level, formal and informal training

2) Gender differences 3) Cultural aspects 4) Aptitude i.e. human intelligence structure 5) Experiences and 6) Personality type. The purpose of addressing the demographics background factors is very importance because the factors are the key indications to suggest the most specific teaching and learning adaptation (DTLA) model for different cognitive and learning style students.

5 Conclusion

Nowadays, to adapt with the requirements from the industry, the quantity surveying programme concerns with the students training in order to enhance the students knowledge and core skills while they were still studying. Essentially, quantity surveying is a profession, which is closely related to architecture that needs to deal with the technical and engineering drawings during the quantification process. As previously mentioned, like architecture, the quantity surveying discipline nature of work would also demand the ability of the profession to create a mental image of the two dimensional (2D) drawings prepared by the architect or engineer and then manipulate it mentally in the forms of three dimensional (3D) drawings in order to quantify the quantities of the items shown in the drawings as accurately as possible. To be specific, the quantification skills are not just about numeracy and calculations, however, it is a complex technical course involving visual and imagination skills from the technical and engineering drawings interpretation.

From the reviews of literature, it can be seen that imagine and visualize construction details is one of the essential attributes and qualities for the quantification skills. Many scholars agreed on the effects of spatial visualization ability (SVA) on learners achievement. Educational theorist believed that integrating cognitive factors such as spatial ability and student-specific characteristics in learning influences students achievement as it was a great concern to enhance the achievement of students with lower spatial abilities.

Essentially, to determine the degree of relationship between the spatial visualization ability achievement scores and the quantification course achievement, it is important to consider the educational implications of differences in students cognitive ability, cognitive and learning styles. Therefore, it is crucial to develop a definitive

teaching and learning adaptation (DTLA) model for different cognitive ability, cognitive and learning style students that can be used to improve the students performance of quantification outcomes. This study struggled to fill the practical and literature gaps that will meet the needs of the quantity programme to promote better academic achievement and anticipated skill requirements (construction measurement skills) among quantity surveying graduates (preferred graduates). The details analysis of the study will soon be ready with completed findings, conclusions and recommendations for future research.

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