INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 14, Issue 2, (2024) E-ISSN: 2222-6990

Visualization Skills among TVET First Year Pre-Service Teachers

Marlissa Omar[1]*, Dayana Farzeeha Ali[2], Fathiyah Mohd Kamaruzaman[3]

[1]Centre for STEM Enculturation, Faculty of Education, Universiti Kebangsaan Malaysia
[2]School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, [3]Centre for STEM Enculturation, Faculty of Education, Universiti Kebangsaan Malaysia

Email: dayanafarzeeha@utm.my, fathiyah@ukm.edu.my
Corresponding Author Email: marlissa@ukm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v14-i2/20086 DOI:10.6007/IJARBSS/v14-i2/20086

Published Date: 25 February 2024

Abstract

Technical and Vocational Education and Training (TVET) is a field that requires technical knowledge and deals with technical skills. Some of the skills needed in this field is visualization skills where students need to be able to visualize the technical aspects during problem solving process. The differences in the background of students enrolling in the TVET programs is a concern which can mean that the level of students in all aspects also varies. TVET pre-service teachers enrolling in higher institutions should have a good visualization skills towards the end of their study to ensure their ability to teach effectively in TVET college or TVET subjects at school. Thus, this article aim to identify TVET first year pre-service teachers' visualization skills before they started to enroll in any courses in the university. 60 TVET first year pre-service teachers is chosen as the respondent in this study. This is a quantitative research which involves visualization test as the instrument to collect the data. The data is then analyzed using descriptive statistics to identify the mean score of the visualization test results. The findings indicate that majority of respondents have a low to moderate visualization skills. This indicates the need to further enhance the TVET pre-service teachers visualization skills to prepare them for their future career as TVET educators in TVET institutions.

Keywords: Visualization Skills, TVET, Pre-service, Teachers

Introduction

Pre-service TVET teachers requires good skills to teach TVET students in terms of technical and vocational skills. One of the skills needed among TVET students is visualization skills. The acquisition of proficient technical drawing skills, particularly via the completion of an engineering drawing course, is of utmost importance for prospective teachers in technical and vocational education and training (TVET) within the university setting. The acquisition of proficiency in technical drawing is imperative due to the fundamental significance of technical drawings within technical and vocational professions.

The precision of technical drawings plays a critical role in the design and manufacturing process, making it essential for technical and vocational practitioners to possess the skills necessary to accurately comprehend and interpret these drawings. According to Shreeshail and Koti (2016), the inability to understand or interpret technical drawings can have a substantial influence on the whole design and production process. According to Sorby et al. (2013), it is crucial to employ visual representations of difficulties before to initiating any procedures in order to prevent the emergence of more complex issues. Therefore, acquiring the skill of creating precise technical drawings accompanied by comprehensive specifications will effectively minimise the occurrence of mistakes during the interpretation of these drawings (Azodo, 2017). There is a need for increased emphasis on comprehensive instruction in the production, comprehension, and interpretation of technical drawings among students pursuing technical and vocational education. This is crucial in order to mitigate the potential risks associated with misunderstanding and failure to accurately comprehend drawings throughout their professional careers in the technical and vocational fields.

According to Kennea *et al* (2023), it is essential for students to possess a foundational understanding of "technical" drawing prior to being introduced to the computer-aided design (CAD) environment. The reason for this is that students do not receive instruction in the usage of drawing boards and set squares as part of their CAD education. The direct exposure of students to the CAD environment may impede their comprehension of fundamental principles in technical drawing, thereby resulting in a detrimental impact on their academic achievement. In addition, the researchers noted in their study that a significant proportion of computer-aided design (CAD) professionals exhibit limited spatial intuition and reasoning abilities. In their study, Zalilov *et al* (2020) observed that individuals with expertise in computer-aided design (CAD) had enhanced visualisation abilities when they possessed a solid understanding of fundamental technical drawing principles. The study shown that engaging in hands-on sketching activities leads to a considerable enhancement in visualisation abilities, in contrast to relying purely on CAD (Computer-Aided Design) instruction.

According to Liu and Yao (2023), a significant number of schools have opted to substitute the engineering drawing class with computer-aided design (CAD) courses. However, it has been observed that these courses often neglect to provide students with an introduction to the conventional methods employed in the production of technical drawings. According to Deng *et al* (2022), the only reliance on computer modelling software does not suffice for cultivating students' spatial comprehension, a crucial skill for effectively comprehending technical drawings. In addition, it has been shown that a significant proportion of students pursuing an technical and engineering degree have limited prior experience in technical drawing (Gomez-Tone *et al.,* 2020). The utilisation of computer-aided design (CAD) without providing students with a comprehensive comprehension of visualisation and projection concepts may result in the inadequate production of high-quality technical drawings, potentially leading to student failure. The deficiency in quality can be attributed to a limited comprehension of how varying angles of projection can yield distinct perspectives in technical illustrations. Thus, as a pre-service teacher soon to be teaching technical and vocational students, they need to have a good visualization skills where they can use that to improve their students' visualization skills which could greatly contribute to the student's career in the future.

Visualization Skills

The development of visualization skills is of utmost importance for technical students in their academic pursuits, as they grapple with complex concepts, elaborate designs, and innovative solutions. An in-depth analysis of the present condition of visualizing skills unveils a multifaceted situation. Zavotka (1986) proposed a categorization of visualization skills, delineating several distinct components. These components include the ability to mentally perceive two-dimensional elements within a three-dimensional context, the capacity to visualize a three-dimensional environment based on a two-dimensional representation, the skill of mentally rotating objects to a different plane, and the aptitude for visualizing objects in relation to scale. According to Buckley, Seery and Canty (2019), mental rotation ability holds particular significance within the engineering domain, as indicated by the aforementioned components. Gomez-Tone *et al* (2020) have underscored the significance of possessing mental rotation abilities among technical students. Enhancing the mental rotation abilities and spatial visualization proficiencies of technical students is expected to provide positive effects on their working memory capacity, hence facilitating their overall learning outcomes.

Technical students frequently demonstrate competence in theoretical comprehension; yet, there is a noticeable deficiency in their ability to effectively convey these insights through visual representations (Wu & Rau, 2019). The difference may be attributed to several factors, including limited access to sophisticated visualization technologies, a lack of practical application within the curriculum, and insufficient focus on the importance of visual communication (Shabiralyani *et al.,* 2015). In order to fully comprehend the necessity of resolving a lack in visualization skills, it is crucial to acknowledge the inherent significance of visualization within technical and engineering fields. 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 *et al.,* 2017). Proficient visualization skills are crucial in the professional realm, since people working in technical field frequently encounter intricate tasks and engage in collaborative efforts spanning several disciplines.

An examination of the difficulties hindering the advancement of visualizing abilities among technical students uncovers a range of complex barriers. The aforementioned issues encompass a notable lack of thorough instruction in widely-used visualization tools within the industry, a curriculum that prioritizes theoretical frameworks over practical implementation, and a common belief that visualization skills are supplementary rather than fundamental. In order to effectively tackle the difficulties that have been recognized, it is imperative to implement strategic interventions. One potential approach to attaining this objective is by use of instructional practices and educational experiences inside the classroom setting. Therefore, it is important for teachers to possess proficient visualization skills and effective instructional methods in order to enhance students' visualization skills within the educational setting. Developing strong visualization skills is crucial for pre-service teachers prior to entering the classroom setting.

Methodology

This research employs a quantitative method to obtain the data. A total of 60 students were used as a respondent in this research. The instrument used to collect the data for this research is Mental Cutting Test (MCT) (Tsutsumi, 2004), Differential Aptitude Test: Space Relations (DAT:SR) (Bennet, Seashore & Wesman, 1947), Purdue Spatial Visualization Test for Rotation (PSVT:R) (Branoff, 2000), and Purdue Spatial Visualization Test for Development (PSVT:D) (Yoon, 2011). In this study, all four tests used which is Mental Cutting Test (MCT), Differential Aptitude Test: Space Relations (DAT:SR), Purdue Spatial Visualization Test for Rotation (PSVT:R), and Purdue Spatial Visualization Test for Development (PSVT:D) was a standard achievement test. Many researchers used these tests mentioned as it has been certified by previous researchers (Scribner & Anderson, 2005; Sorby & Baartmans, 2000), which have very high validity and reliability. Table 1 shows the value of Alpha Cronbach for the instruments used in this study.

Table 1
Alpha Cronbach Value for the instruments used in this research

Instrument	Alpha Cronbach Value
Mental Cutting Test	0.803
Differential Aptitude Test: Space Relations	0.801
Purdue Spatial Visualization Test for Rotation	0.804
Purdue Spatial Visualization Test for Development	0.805

To analyzed the data, which is the results of the visualization tests, the raw scores obtained are converted to percentage manually and inserted in the SPSS software. The data that has been converted to percentage is then analyzed using descriptive analysis to find the mean scores and the standard deviation. The mean score obtained is used to determine the skills level of students. The researcher used the interpretation of visualization skills level based on the visualization skills test. Table 2 shows the interpretation of visualization skills level based on the visualization skills test.

Table 2
Visualization skills level interpretation (Sorby, 2009)

Mean Score (Percentage)	Score Level of Space Ability	Level of Visualization Skills
61 – 100	Above average score	High
41 – 60	Slightly below average score	Moderate
0 - 40	Below average score	Low

Data Analysis and Findings

The table presents the results of a visualization test across three different tests: the Mental Cutting Test, Differential Aptitude Test: Space Relation, Purdue Spatial Visualization Test for Development and Purdue Spatial Visualization Test for Rotation. The findings are summarized based on the mean score, and standard deviation for each test as shown in table 3.

Table 3
Visualization test result

Visualization Test	No. of Respondents	Mean Score	Standard Deviation
Mental Cutting Test	60	25.449	16.310
Differential Aptitude Test: Space Relation	60	46.850	20.288
Purdue Spatial Visualization Test: Development	60	46.080	18.892
Purdue Spatial Visualization Test: Rotation	60	58.778	24.355

The MCT involves presenting students with a perspective drawing of a three-dimensional object, which is then intersected by an imaginary plane. Subsequently, students are required to select the most accurate cross-section from a set of five options. According to the data presented in Table 3, the outcomes of the MCT reveal a mean score of 25.449, with a standard deviation of 16.310. Based on the interpretation of visualization skills levels as proposed by Sorby (2009), the mean score obtained falls under the category of below average scores, suggesting a relatively low level of visualization skills among the respondents. The calculated standard deviation of 16.310 indicates a substantial level of dispersion across the individual results, indicating that certain participants obtained values that deviated considerably from the mean, either in a higher or lower direction.

The second visualization test, known as the DAT:SR, is utilized to assess an individual's aptitude for manipulating objects in three-dimensional space. The provided questions necessitate students to select a single accurate depiction of three-dimensional objects from a given object layout. Students are required to choose the solutions that accurately depict the configuration of the unfolded figures upon folding. Based on the data provided in Table 3, the results of the DAT:SR indicate a mean score of 46.850, accompanied by a standard deviation of 20.288. According to Sorby's (2009) interpretation of visualization skills levels , the average score obtained by the respondents indicates a moderate degree of visualization abilities. The calculated standard deviation of 20.288 suggests that there is a moderate degree of diversity in the results, indicating that some respondents exhibit a greater range of visualization skills. The next test is PSVT:D, which was designed to measure students capacity to mentally generate 3D objects. According to the data in Table 3, the respondents' mean score is 46.080, with a standard deviation of 18.892. The mean score of 46.080 is nearly identical to the mean score of respondents in the DAT:SR test, demonstrating a consistent level of spatial ability. This exam's standard deviation of 18.892 indicates a significant degree of variability in individual results, as well as some variation in respondents' performance on the test.

PSVT:R is the last test employed in this study, and it requires students to identify the proper three-dimensional objects after they have been rotated to a specific angle of rotation. According to the data in Table 3, the respondents' mean score is 58.778 with a standard deviation of 24.355. The greater standard deviation of 24.355 implies a broader range of scores, with some respondents excelling in this area while others may find it more difficult to solve the tasks.

Discussion and Conclusion

The results of this study indicate that there are differences in spatial visualization skills across the respondents, with certain individuals demonstrating exceptional performance in particular types of visualization tasks. The variations in the mean scores and measures of variance among the tests offer valuable insights into the heterogeneous nature of spatial reasoning abilities within the examined group. The development and use of visualization skills are of paramount importance in the realm of education and professional practice within technical disciplines. As individuals advance in their academic endeavors, disparities in their aptitude for conceptual visualization and problem-solving become apparent. Certain students exhibit an inherent aptitude for spatial intelligence, which facilitates their ability to mentally comprehend and manipulate objects within three-dimensional space. Some individuals may encounter difficulties with spatial activities, which might have an affect on their capacity to comprehend intricate concepts. Furthermore, disparities in individuals' prior educational experiences may lead to variations in their ability to visualize. Individuals who possess a solid understanding of mathematics and physics may experience more ease in comprehending topics related to visualizing. In addition to this, educational programs that include visual aids, simulations, and experiential learning opportunities have been seen to positively impact students' ability to visualize concepts. The variances in instructional approaches might have an influence on students' aptitude to effectively apply theoretical information in practical contexts. In conclusion, the variances in the visualization abilities of engineering students may be attributed to a confluence of several elements. It is imperative for teachers to acknowledge and confront these disparities in order to provide inclusive educational settings that accommodate a wide range of learning preferences and capabilities. This, in turn, will promote a fair and efficient technical and vocational education system.

Acknowledgement

The authors would like to thank Universiti Kebangsaan Malaysia, grant number GGPM-2022-019 for the funding of this research.

References

Azodo, A. P. (2017). Attitude of engineering students towards engineering drawing: A case study. *International Journal of Research Studies in Education*, 6(1), 61-74.

Bennett, G. K., Seashore, H. G., & Wesman, A. G. (1947). Differential aptitude tests.

Billger, M., Thuvander, L., & Wästberg, B. S. (2017). In search of visualization challenges: The development and implementation of visualization tools for supporting dialogue in urban planning processes. *Environment and Planning B: Urban Analytics and City Science,* 44(6), 1012-1035.

Branoff, T. J. (2000). Spatial visualization measurement: A modification of the Purdue Spatial Visualization Test—visualization of rotations. *The Engineering Design Graphics Journal,* 64(2).

Deng, Y., Mueller, M., Rogers, C., & Olechowski, A. (2022). The multi-user computer-aided design collaborative learning framework. *Advanced Engineering Informatics*, 51, 101446.

Gómez-Tone, H. C., Martin-Gutierrez, J., Valencia Anci, L., & Mora Luis, C. E. (2020).

International comparative pilot study of spatial skill development in engineering students through autonomous augmented reality-based training. *Symmetry*, 12(9), 1401.

Kennea, P., Siena, F., Forbes, C., Malcolm, R., Martin, L., Stewart, J., ... & Pope, D. (2023). CAD bash: accelerating 2D/3D computer aided design competencies for first year product design students. *The Design Society.*

Liu, X., & Yao, R. (2023). Design of Visual Communication Teaching System Based on Artificial Intelligence and CAD Technology. *Computer-Aided Design and Applications,* 20(S10), 90-101.

McLaren, S. V. (2008). Exploring perceptions and attitudes towards teaching and learning manual technical drawing in a digital age. *International Journal of Technology and Design Education*, 18, 167-188.

Scribner, S. A., & Anderson, M. A. (2005). Novice drafter'spatial visualization development: Influence of instructional methods and individual learning styles. Retrieved June 18, 2007.

Shabiralyani, G., Hasan, K. S., Hamad, N., & Iqbal, N. (2015). Impact of visual aids in enhancing the learning process case research: District Dera Ghazi Khan. *Journal of education and practice*, 6(19), 226-233.

Shreeshail, M. L., & Koti, C. M. (2016). Augmenting the out of classroom learning of machine drawing laboratory course. *Journal of Engineering Education Transformations*, 29(4), 37-41.

Sorby, S. A. (2009). Educational research in developing 3-D spatial skills for engineering students. *International Journal of Science Education*, 31(3), 459-480.

Sorby, S. A., & Baartmans, B. J. (2000). The development and assessment of a course for enhancing the 3-D spatial visualization skills of first year engineering students. *Journal of Engineering Education*, 89(3), 301-307.

Sorby, S., Casey, B., Veurink, N., & Dulaney, A. (2013). The role of spatial training in improving spatial and calculus performance in engineering students. *Learning and Individual Differences*, 26, 20-29.

Tsutsumi, E. (2004). A Mental Cutting Test using drawings of intersections. *Journal for Geometry and Graphics*, 8(1), 117-126.

Wu, S. P., & Rau, M. A. (2019). How students learn content in science, technology, engineering, and mathematics (STEM) through drawing activities. *Educational Psychology Review*, 31, 87-120.

Yoon, S. Y. (2011). Psychometric properties of the revised purdue spatial visualization tests: visualization of rotations (The Revised PSVT: R). Purdue University.

Zalilov, R., Reshetnikova, E., Savelyeva, I., Svistunova, E., Rebezov, M., Goncharov, A., ... & Odinokova, E. (2020). CAD systems and computer graphics in the training of specialists in the field of mechanical engineering. *Journal of Critical Reviews*, 7(2), 162.

Zavotka, S. L. (1986). Analysis of three dimensional computer graphics animation to teach spatial skills to interior design students. *Journal of Interior Design*, 12(1), 45-52.