Longitudinal Assessment of Spatial Skills Development in MET Students

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WIP: Beginning of Longitudinal Assessment of Spatial Skills Development in MET Students

Abstract

This work in progress (WIP) research focuses on beginning systematic and regular administration of the Purdue Spatial Visualization Test: Rotations (PSVT:R) to Mechanical Engineering Technology (MET) students in a MET department. The work aims to reveal patterns of spatial skills development, providing valuable insights for curriculum design, teaching methodologies, and support mechanisms. Beyond traditional assessments, the research explores correlations between improved spatial skills and industry-valued qualities, underscoring the potential of non-traditionally assessed skills in predicting long-term success. Additionally, the investigation examines spatial ability as an indicator of MET-specific performance. This research addresses critical gaps in spatial skills assessment practices, contributing insights to enhance MET education and inform pedagogical strategies.

Introduction

Spatial skills are crucial for the success of engineering students, particularly in disciplines like Mechanical Engineering Technology (MET). The Purdue Spatial Visualization Test: Rotations (PSVT:R) has long been a recognized diagnostic tool for gauging spatial aptitude, especially at the beginning of engineering curricula.

This research aims to formalize and expand the application of the PSVT:R within the MET Department at ___ by adopting a longitudinal approach. Plans are for the instrument to be systematically and regularly administered throughout the course of study of MET students. Currently, PSVT:R results are solely used as diagnostic instruments within the department. Having a publication validating use of the PSVT:R can potentially help use of instrument beyond the department and college of engineering.

In addition to its traditional role in assessing spatial aptitude, this research explores potential correlations between improved spatial skills and broader skill sets, including enhanced motor skills, tactile abilities, and the capacity to perform mechanical tasks. Aspects often emphasized by industry representatives, these qualities are integral for developing well-rounded MET graduates.

Background

The study of spatial and visualization skills (SVS) has been a focal point for researchers, and the authors of this work have made significant contributions to the understanding of SVS within the educational context. Extensive research has been conducted to explore the implications of SVS in the success of students, particularly in Science, Technology, Engineering, and Mathematics (STEM) disciplines. Past research has shown that spatial ability as measured by the PSVT:R is significantly correlated with both problem solving and problem representation, and the test appears to measure an aspect of thinking that is not measured by the SAT or ACT math tests (Duffy, Power,

Sorby, and Bowe, 2018). Both problem solving and problem representation are important to the success of students majoring in MET.

The literature on SVS consistently demonstrates a positive correlation between strong spatial skills and achievement in STEM fields. Recognizing the predictive power of SVS for success in engineering graphics courses, the PSVT:R has emerged as a normed instrument for assessing spatial aptitude. The use of normed instruments, like the PSVT:R , allows for a standardized measurement of spatial skills, enabling a comparative analysis of students' abilities.

One of the notable findings of PSVT:R across settings is differences between genders and that typically males score higher than females (Sorby, 2009; Maeda & Yoon, 2013). It is important when presenting such information to students to include an interpretation of the data - e.g. it is often not an innate ability, but rather a combination of social factors that contribute to the reasons for such skill development. It is also important to note that spatial ability is a skill and not a talent, thus improvement through thoughtful engagement is possible. Remediation done specifically to improve visualization ability has been shown to increase retention in women and minorities in engineering majors (Lubinski, 2010).

Traditionally, such tests have been employed in a summative fashion, providing a snapshot of students' aptitude at a particular point in time. In the current competitive educational environment, there is a growing interest in using these assessments strategically. The results of SVS assessments, like the PSVT:R, can serve not only as indicators of potential success in STEM but also as recruitment tools and placement instruments.

In an era where student populations are increasingly competitive, showcasing the potential for success in STEM through SVS assessments becomes an asset for educational institutions. The authors envision extending the use of normed instruments, like the PSVT:R, across departments within the engineering school on campus. Furthermore, the long-term goal is to integrate these assessments campus-wide, recognizing the broader applicability of SVS indicators in diverse academic disciplines.

Current PSVT:R Usage

In the current educational setting, the PSVT:R has primarily served as an informative tool, with no formal diagnostic or longitudinal data collection. The administration of the PSVT:R is integrated into the instructional process for students enrolled in a 100-level engineering graphics class. Typically, students taking this assessment are in their first year, either during the first or second semester.

Notably, no longitudinal data has been collected from any students thus far at the current setting, meaning that no post-tests or follow-up assessments have been administered. However, a significant development occurred during the current academic year, as seniors in the Mechanical Engineering Technology (MET) program were introduced to the PSVT:R as a routine part of classroom instruction. The purpose of this implementation was to have a base level of data to compare the scores of the general population of seniors to the general population of first-year students to see if there was a significant difference in their scores.

Like many engineering and engineering technology majors, the entrance to major requirements in the MET major at ___ are grades of a C or above in mathematics and physics courses. Currently, the grades in engineering graphics courses, along with other introductory major courses, are not considered in the entrance to major applications. It is of interest to the researchers to see if there is a significant correlation between visualization abilities as measured by the PSVT:R, performance in introductory engineering graphics courses, and success/retention in the major. If there is a significant correlation, potential changes in entrance to major requirements could be considered.

Data Collection

For this research, data were collected from two distinct groups of students: freshmen and seniors in the MET program. A total of 22 freshmen and 24 seniors participated in this assessment. The data collected from these students were subjected to statistical analysis (at the time of submission, descriptive statistics are being calculated and will appear subsequently).

At the time of revision, a second round of administration is being collected as circumstances allow. The same populations of participants as earlier in the year will be considered. In the future, first-year students' PSVT:R results will be collected in the introductory engineering graphics course, and student success through the major will be tracked, with students taking the assessment again when enrolled in the senior project course.

Summary of Findings

The analysis of the collected data revealed preliminary insights into the spatial and visualization skills of freshmen and seniors in the MET program. Freshmen exhibited an average score of 23.7 out of 30 on the PSVT:R, while seniors scored slightly higher with an average of 24.5. Further examination of the data will be necessary to identify potential differences in spread and median between the two groups.

Initial observations suggest that seniors may exhibit a smaller spread in their scores, indicating a more consistent performance. This could be interpreted as, barring outliers, seniors tend to perform better on the PSVT:R compared to freshmen. Additionally, it is worth noting that the literature suggests that once a certain threshold is reached (e.g., above 20), further discrimination in scores may not necessarily reflect additional performance gain. In other words, a score of 22 versus 23 may not significantly impact the interpretation of spatial skills, as both are considered strong.

Further Analysis

While this initial analysis provides valuable insights, there are additional analytical methods that can be employed, such as factor analysis and item response theory, to gain a deeper understanding of the findings. These methods can help elucidate the underlying factors contributing to spatial skills and provide a more nuanced perspective.

One of the primary goals of this research is to showcase the potential benefits of quantifying spatial skills, not only for academic purposes but also for potential collaborations on campus.

Demonstrating the utility of PSVT:R scores can open doors to collaborations with other departments and programs, highlighting the significance of spatial skills in various fields of study.

Demographics to consider in future analysis include controlling for transfer students, non-traditional students, gender, and those suggested at the time of review. The campus at ___ has a prominent population of said students and it would be beneficial to capture trends.

Partnerships between authors and local high schools are another potential use of results. A large high school in ___ has strong vocational and CTE (Career and Technical Education) programming that historically has fed into the MET program at ___. At recent industrial advisory board meetings to ___ High School, it has been communicated that recruitment to the CTE program has been down in recent years. Faculty at ___ High School have been open to educational research like the PSVT:R. Demonstrating alternative measures of aptitude for CTE and STEM through participation in instruments and measures like the PSVT:R may be an option for students.

Traditionally, mathematics has proven to be a barrier to students considering pursuing majors in engineering and engineering technology. Although a foundation in mathematics is necessary for many engineering technology courses including, statics, dynamics, heat transfer, and so on, some students who have not had the opportunity to take higher level math in high school, or who did not test into Calculus I when beginning their college studies, are prevented from even starting engineering studies and not given the opportunity to gain the mathematics skills necessary to succeed. If a correlation between visualization abilities as measured by the PSVT:R and success in the MET major can be shown, more students may consider pursuing engineering majors while succeeding in introductory major courses and developing the necessary mathematics skills for successful degree completion.

Moreover, it is worth considering that the activities incorporated into the MET course of study may contribute significantly to PSVT:R performance. By its nature, coursework in MET tends to have significant amounts of lab activities that include working with equipment and tools where engineering theory is applied to practice. The nature of these hands-on activities throughout the curriculum could contribute to retention because studies have found that students, especially those in underserved populations, who received visualization remediation via hands-on activities, not only improved their PSVT:R scores, they also had higher retention rates in their majors, and higher GPAs when compared to students who had not received remediation (Study, 2011). Further exploration of the relationship between specific coursework and spatial skills development could yield valuable insights. This preliminary analysis serves as a foundation for deeper investigations into spatial skills within the MET program. While the data shows promising trends, further examination and collaboration are essential to unlock the full potential of spatial skills assessment and its impact on education and interdisciplinary cooperation.

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