Developing an Interactive Spatial Visualization Gaming Instrument (SVGI) for Exploring Assessment Retention and Scoring Improvements Utilizing the Purdue Spatial Visualization Test of Rotations

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Abstract

This research investigated a relationship between discernible spatial ability skills and a sample's overall performance in introductory vector graphics courses, as well as observations on test retention within conventional paper forms of the Purdue Spatial Visualization of Test of rotations (PSVT), and the interactivity related to cognitive ergonomics of interface and the human users with a non-conventional form of the PSVT toward the development of an Interactive Spatial Visualization Gaming Instrument (SVGI). Additionally this study examined comparable research on concepts of spatial ability, and reviewed results associated between successes and limitations in technical graphics' courses and efforts to increase retention and performance in spatial ability that has been connected to demonstrate participants analytical processing capabilities.

Introduction

Educators and curriculum developers employ a diversity of well-established pedagogical theory and practicum in addressing individual learning styles. Testing and assessment is more authentic when learners are evaluated for their best abilities of information they have learned in a realistic environment (Sluk, 2005). Spatial visualization as a skill is fundamental for those working and studying in the field of engineering, as well as those individuals in technology professions that work with a diversity of vector graphic tools designing in three-dimensional space and virtual environments (Branoff, 2000), (Gorska, et al, 2001), (Yue, 2006). Within this motivation, spatial visualization has long been considered an essential component toward careers using and interpreting graphics technologies (Smith & Strong, 2002). Yet, despite the significance of this skill, large segments of the general populace do not perform well when confronted with spatial-visual relations tasks (Ben-Chaim, et al, 1997).

For 21st Century students enrolled in courses that focus on developing spatial visualization skills, it was proposed that an interactive testing instrument with, "gaming" features and characteristics would increase student scores when compared to more traditional paper and pencil testing instruments. The purpose of this research was to explore whether more interactive forms of the Purdue Spatial Visualization Test (PSVT) would offer greater retention and produce higher scores in a population of students enrolled in technical illustration/vector graphics courses. The goal of this research was to investigate observations of the cognitive ergonomics of interface and the human users' interactivity with conventional PSVT instruments and experimental forms.

Spatial visualization ability is vital to success in a variety of careers and fields of study. Engineers, scientists, mathematicians, and creative designers that rely on an ability to spatially visualize theories and practicum (Baartmans & Sorby, 1996). Spatial visualization as a skill is fundamental for those working and studying in the field of engineering, as well as those individuals in technology professions that work with a diversity of vector graphic tools designing in three-dimensional space and virtual environments (Branoff, 2000), (Gorska, et al, 2001), (Yue, 2006). For this reason, spatial visualization has long been considered an essential component toward careers using and interpreting graphics technologies (Yue, 2006). Yet, despite the importance of this skill, large segments of the general populace do not perform well when confronted with spatial-visual relations tasks (Ben-Chaim, et al 1997).

While spatial visualization has been central to technical graphics curriculum development for decades, the emphasis on its importance has increased largely due to the vast changes in computer technology (Ben-Chaim, et al, 1997), (Yue, 2006). These developments in imagining technologies have revitalized educators' interest in spatial visualization. Therefore, spatial visualization has become a required skill for engineering and technology students (Yue, 2006). In addition to considering the history and philosophies encompassing spatial visualization, as well as the broader associations within Math, Science, and Social Sciences, these academic concentrations and disciplines have additionally contributed to spatial visualization research (Yue, 2006). With all these continued and expanding interests in spatial research, many designs and instruments have been developed for testing spatial visualization within the perspective of cognition and perception (Yue, 2006). The goal of this research is to expand and build upon that canon of study.

In reviewing comparable research, a diversity of spatial visualization testing instruments have been used by educators as both teaching and research tools at many colleges over the decades. These practices have been shown to improve visual spatial skills and have improved retention of engineering students (AWEP, 2005), (Yue, 2006). A variety of academic textbooks provide various formats of spatial visualization exercises, quizzes and tests on spatial visualization (Yue, 2006). In many cases, educators have conducted pre-test, treatments, and post-test assessments in order to diagnose and improve students' visualization skills for a diversity of graphics and computer aided design (CAD) courses (Yue, 2006). In many instances, the most commonly used spatial visualization test has been the Purdue Spatial Visualization Test (PSVT), Figure 1. Yet regardless of the choice from the variety of testing instruments, spatial visualization testing involves complicated, multi-step manipulations of spatially presented information (AWEP, 2005). These tasks require the subject to analyze the relationship between different spatial representations, rather than just matching of those representations. Mental rotation and spatial perception may or may not be elements of the analytic strategy required to complete the task (AWEP, 2005). In addition, the format of spatial visualization may also require some prior knowledge of engineering and technical graphics, such as the concepts of "point of view" and "isometric projection". Therefore, it may not be appropriate for testing a general audience. There are also some issues with the application of the format in spatial visualization (Yue, 2006).

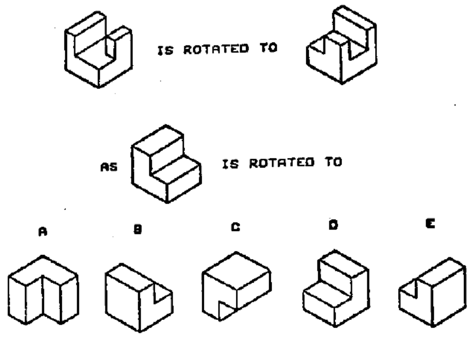

Figure. 1 Purdue Spatial Visualization Test (PSVT)

Spatial visualization tests have also been frequently used to assess and improve retention rate of freshmen, women, and minority engineering and technology students (AWEP, 2005), (Yue, 2006). Educators have also used spatial visualization tests to study human visualization behaviors in the context of age, gender, education, and training (Yue, 2006). As an expression, spatial visualization has been interchangeable with the broader terms of visualization, spatial ability, and spatial orientation spatial ability is probably and silently the most vital aspect of the human mental capabilities (Yue, 2006). In our daily lives, graphical communication has become increasingly important through the emergence of computer graphics and multimedia applications. For this reason, spatial visualization has long been considered fundamental in a diversity of technical graphics courses. This increased awareness the importance of spatial visualization skills is extended to participation, success and retention of operatives, especially women in science, technology, engineering, and mathematic (STEM) fields (AWEP, 2005), (Gorska, et al, 2001), (Hamlin, et al, 2008), (Yue, 2006).

Method

The goal was to produce a series of interactive testing instruments [Spatial Visualization Gaming Instruments] (SVGI) that considers students' "testing styles" comparing those SVGI outcomes to the conventional instrument results. In preliminary research, results were compared for both the traditional paper instruments of the PSVT an interactive, static-image online PSVT testing instrument.

Initially the interest in exploring the development of a SVGI model was proposed when a noticeable percentage of a sample of young participants taking a paper version of the PSVT scored well on the first-half to two-thirds of the thirty-question test, while few scored significantly on the last one-third rotations. The PSVT was designed in the 1970s and has been used virtually unchanged since then. The test was not designed to be more difficult as one progressed through the test. The older students above the mean age of 21 scored better overall with a better spread of correct answers than those participants at the mean age or below. It was this observation that led to the hypothesis of developing a better testing instrument. Several questions that have been proposed: Could a more engaging PSVT increase the younger students' retention and focus? Could a visualization gaming instrument be used to increase a students' performance in graphical education, as well as could this difference be measured and probability tested?

Results

Initial observations: a 2011 sample of 35 undergraduates enrolled in a technical graphic course that were given a conventional paper version of the Purdue Spatial Visualization Test (PSVT) at end of their course. The goal was to observe whether there were any discernible associations of final grades scores and PSVT scores based on age and gender. Identifiable occurrences were documented through variance testing. For sub-group comparisons a Paired T- Statistics was performed. Based on those findings, additional proportion tests, and non-parametric tests were applied to ascertain any additional probabilities. That research concluded there was no evidence of a difference in the visualization skills and gender with both groups scoring a mean score of 60% correct. However gender did have a role in final grades. Based on averages, females scored higher than males by 8 points on average on final grades. Did the PSVT scores have any observable connection to the samples over all Final Grades? The only evidence that points to any significance of influence was the test of proportions. The female students that scored a perfect score of 100 (A) for their final grades, there was a return of influence based on the success of scoring the average on the PSVT (p: proportion of successes H_0: $p = 0.5$; H_A: $p \neq 0.5$). A presentation of this research was presented at the International Association of Technology, Education and Development (IATED) Conference in Madrid, Spain, 2011 (Blue, 2011).

Final Grade	Count	Total	Sample Prop.	Std. Err.	Z-Stat	P-value
100	0	9	0	0.16666667	-3	0.0027

Table 1: Success -60, Where - Gender =F, Grouped by - Final Grade

Additional observations from that 2011 research initiated the proposition for the Spatial Visualization Gaming Instruments (SVGI) model; a high percentage of the 2011 paper-test sample failed the last one-third of the paper test's questions. The PSVT was not designed to be more difficult as one progressed through the test. The PSVT was designed in the 1970s and has been used virtually unchanged. It was then proposed that a more engaging PSVT instrument might increase younger students' retention as well as offer evidence to specific testing styles.

In the spring of 2012, a preliminary SVGI (online PSVT) instrument was pilot-tested as a pretest to 22 students enrolled in Technical Graphics course. When this pre-treatment sample was assessed about their individual spatial visualization experiences, only 4 out of the 22 participants documented any previous familiarity in technical graphics or working with 2D/3D modeling. The SVGI instrument was posted on the course's Blackboard with identical 30-questions sequence as the paper version. Students received questions delivered one-at-a-time with an immediate score of their efforts upon completion.

Column	n	Mean	Variance	Std. Dev.	Median	Range	Min	Max
Paper PSVT	35	60.28	301.32	17.35	63	69	27	96
Online SVGI	22	67.42	305.74	17.49	63	60	40	100

Table 2: Summary statistics: Two Samples (Paper and SVGI)

In discussing these two instruments' results from the 2011 "post-treatment" paper-test PSVT group to the 2012 "pre-treatment" SVGI sample (Table 2), the sample that participated in the pre-treatment SVGI version had a nearly 8 point higher average in outcomes. It should be noted that these two groups are not comparable nor applicable for significance testing based on uncontrolled variables The results of the 2012 pretreatment sample only demonstrates that this group scored higher on their PVST electronic test than the 2011 post treatment group. Additionally, the post-treatment scores for the 2012 electronic PSVT group demonstrated an average score of 73.

In comparing these two sample cohorts from 2011 and 2012, it should be noted that they are not comparable and it would be difficult to draw any tangible conclusions at this stage of ongoing research. Because the initial 2011 research lead to the secondary 2012 research, validity would need to be addressed as the instruments moved from the paper based test to the computer based test. Therefore further research is required. The 2011 observations provided possible clues toward trends in addressing student retention, and the preliminary assumption was pilot tested with the 2012 sample. Pedagogy endorses the variety of learning styles in developing curriculum delivery whereas more often testing and assessment are typically based on more traditional models. Observing that students perform better with interactive technologies should inspire more study.

Discussions

More recently funding for subsequent research has been awarded to develop a more interactive version, (SVGI 2.0) with gaming features and characteristics that utilizes the PSVT of rotations to engage the "gamers" in a narrative to achieve the goals of finishing the test. PSVT 2.0 is designed with intuitive visual and audio feedback responses with the intention of to increasing retention and enhances the assessment experience. SVGI 2.0 testing is scheduled for the fall of 2012.

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As an expression, spatial visualization has been interchangeable with the broader terms of visualization, spatial ability, and spatial orientation spatial ability is probably and silently the most vital aspect of the human mental capabilities (Smith & Strong, 2002), (Yue, 2006). In our daily lives, graphical communication has become increasingly important through the emergence of computer graphics and multimedia applications. It is this purpose, spatial visualization has long been considered fundamental in a diversity of technical graphics courses. There is an increased awareness of the importance of spatial visualization skills is extended to participation, success and retention of workers in science, technology, engineering, and mathematic fields (AWEP, 2005), (Gorska, et al, 2001), (Hamlin, et al, 2008), (Yue, 2006). The sample of students in these courses had a treatment of a variety of hands-on and computer-related. In discussing the cognitive ergonomics of interface and the human user, the paper-test results for the 2011 group of youths initiated several questions regarding interactivity and retention with the use of conventional forms of assessment. Though the latter 2012 group performed better using the electronic version of the PSVT at the pretest and posttest levels, it was noted that the measurable results were not significantly comparable, yet the differences in a improved spread of scores within the interactive assessment as compared to the paper test was observable. The next phase of the development of the more interactive gaming electronic PSVT is projected to provide both measurable results and increase student performance in spatial visualization.

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