Correlation of Haptic Abilities and Improvement of Visualization Skills in a Sample of Minority Engineering and Technology Students

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ABSTRACT *- Sketching and the use of manipulatives, along with other activities, has been shown to increase the visualization abilities of students who scored below the expected mean on the Purdue Spatial Visualization Test (PSVT). Because of the success of these activities, it was of interest to see if there was any correlation between haptic ability as measured by the Haptic Visual Discrimination Test (HVDT) and improvement in PSVT scores. Some students enrolled in courses that included activities specifically designed to improve their visualization abilities also volunteered to take the HVDT. The mean of the HVDT scores was within the norm for their age group. There was a positive correlation between PSVT scores and HVDT scores. The gain scores on the PSVT were negatively correlated with the HVDT scores.*

I. Introduction

Minority students who enroll in majors in the STEM fields have rates of retention and graduation that are lower than those of their non-minority peers (Tan, 2002; White, 2005) and their overall numbers do not reflect their percentages in the United State population (Gibbons, 2008). As part of the effort to improve classroom success and retain students in their majors, several years of data have been collected on subjects enrolled in engineering and technology majors at an historically black university (HBCU). These students have traditionally performed well below the expected mean in their visualization abilities as measured by standard tests such as the Purdue Spatial Visualization Test (PSVT), the Mental Cutting Test and the Lappan test. Since visualization is an important component of success in STEM fields, efforts were made to improve these students' visualization abilities and increase long-term success in their studies. These students' visualization test scores were found to increase significantly after completing specific class work and homework activities focused on remediation, including sketching and the use of manipulatives, throughout the course of a semester (Veurink, Hamlin, et.al., 2009; Study, 2009).

Many of the students who participated in the previous studies on visualization abilities also took part in additional research where they were administered the Haptic Visual Discrimination Test (HVDT). The HVDT is a standardized quantitative test that measures tactile sensitivity, spatial synthesis and the ability to integrate partial information about an object into a whole (McCarron & Dial, 1979).

Since sketching and the use of manipulatives was shown to increase the students' posttest visualization scores, it was of interest to see if there was any correlation between haptic ability as measured by the

HVDT and improvement in PSVT scores for this group of students.

II. The Tests in the Study

The Purdue Spatial Visualization Test: Visualization of Rotations (PSVT) is a 20 minute timed test that consists of 30 items of varying difficulty. There are four types of items; one type requiring rotation of 90° about one axis, another requiring rotation of 180° about one axis, one requiring rotation of 90° about two axes, and the fourth requiring rotation of 90° about one axis and 180° about another axis (Guay, 1976). An example is shown in Figure 1.

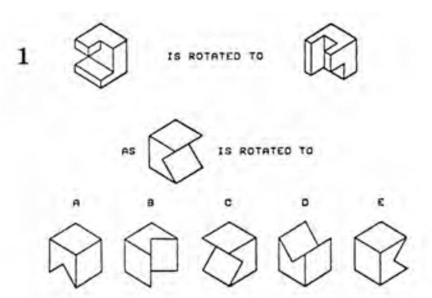

Figure 1. PSVT (Guay, 1976)

The Haptic Visual Discrimination Test (HVDT) is individually administered and the subject sits across from the examiner at a testing table. An identification chart is placed in front of the subject along with a visual screen. The case containing the test objects is placed in a position where the subject cannot view the objects. The subject places their right hand through the opening in the visual screen and the examiner places an object in their hand. The subject is allowed to manipulate the object in their right hand without seeing it, and then is asked to point to the corresponding object on the identification chart with their left hand.

A picture showing the typical setup of the testing environment from the test examiner's perspective is shown in Figure 2. There is no set time limit to administer the HVDT and the average time required by subjects in this study was 10 to 15 minutes. Scores were recorded on a standard score sheet by the examiner.

Figure 2. HVDT setup from examiner's perspective

III. Test Results

The 143 PSVT scores used to calculate the grand mean were compiled from different studies including Veurink, Hamlin, et.al., (2009), and Study (2004, 2006, 2009). The subjects were all engineering, engineering technology, or industrial technology majors enrolled in introductory engineering graphics courses at Virginia State University, an HBCU. The average age was 19, eighty-seven percent were male, and ninety-eight percent self-identified as black. The grand mean of the pretest PSVT scores for all subjects was 15.4 and the mean posttest score was 20.21.

The Haptic Visual Discrimination Test was administered to 40 subjects who had also participated in the courses with remediation intended to improve their visualization scores. The mean PSVT pretest score for these 40 subjects was 15.1 and the mean posttest score was 21.0, which was not significantly different from the grand mean for all subjects in the previous studies.

The HVDT raw scores ranged from 23 to 41 with a mean of 34.85 and a standard deviation of 3.96. The mean was within the norm based on scaled scores.

For analysis, HVDT raw scores are converted to scaled scores with a scaled score of 10 representing the mean of raw scores. Scaled score deviations of 3 equal one standard deviation. A score within the range of 7 to 13 indicates normal performance (McCarron & Dial, 1979). Scaled scores for the age range of subjects in this study are shown in Table 1.

Although the mean of the HVDT scores was within the norm for the age range of the subjects, eight of the 40 subjects scored below the range of normal performance. The mean pretest PSVT score for these eight subjects was 11 and the mean posttest score was 18 which is still below the expected mean.

Scaled Score	Age 17-Adult
20	
19	47-48
18	46
17	45
16	43-44
15	42
14	41
13	39-40
12	38
11	37
10	35-36
9	34
8	33
7	31-32
6	30
5	29
4	27-28
3	26
2	25
1	23-24

Table 1. HVDT Table of Norms for Ages 17-Adult (McCarron & Dial, 1979)

IV. Analysis

Previous analysis of the correlation between visualization abilities as measured by the PSVT and haptic abilities as measured by the HVDT showed no significant correlation (Study, 2001). However, that study only used pretest PSVT scores and the subjects were predominantly non-minority. Those subjects also had mean PSVT pretest scores that were at the expected mean, and HVDT scores that were at or above the range of normal performance for their age group.

The pretest PSVT scores for all subjects in the current study were positively correlated with HVDT scores at r = 0.533. The posttest PSVT scores were positively correlated with HVDT scores at r = 0.629. The gain between pre and posttest PSVT scores was negatively correlated with HVDT scores at r = -0.366. It must be noted that the mean gain score for those individuals who were below average in their HVDT scores was 7.0 while the mean gain score for those who were average or above average in their HVDT scores was 5.5. However, there are not enough subjects in the study to make any statistical conclusions about this result.

V. Discussion

Even though hands on activities had been shown to improve visualization abilities in subjects with below average scores on the PSVT, based on previous research findings it was expected that there would be little or no correlation between visualization ability and haptic ability as measured by scores on the PSVT and HVDT. However, for the subjects in this study, there was a positive correlation between the test scores indicating that normal to above average haptic abilities were associated with higher visualization abilities.

Those subjects who had haptic abilities that were below the norm for their age group, had visualization abilities that were lower than the mean of the other subjects in this study. Also, note that the mean PSVT score for all subjects in this study is below the expected mean, which prompted the initial studies designed to improve their visualization abilities. Even though the visualization abilities of the subjects with low haptic abilities increased after remediation, the posttest PSVT scores were still below the expected mean for all subjects, and below the grand mean in this study.

The negative correlation between the gain scores, from pretest to posttest on the PSVT, and haptic ability indicates that subjects who are below the norm in their HVDT scores still benefited from the visualization remediation coursework. The students who had higher haptic abilities, tended to have higher pretest PSVT scores, thus the gain between their pre and posttest scores was less, a mean of 5.5 compared to the mean of 7.0 for those with lower haptic abilities. It is not clear from these results which aspects of the coursework were most beneficial to the subjects with lower haptic abilities, because even though their mean gain scores were higher than those of the other subjects, their posttest scores were still below the expected posttest mean for similar subjects.

With only 40 test subjects who have taken both the HVDT and PSVT, and only 8 subjects who scored below the expected norm on the HVDT, it is not possible to draw any statistical conclusions at this point. Data will continue to be collected and analyzed to determine if the results of this study were an anomaly due to the small sample size.

VI. References

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