A "New" Visualization Assessment for Engineering Graphics Courses

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Abstract

The Biewald Orthographic Visualization Battery (BOVB) represents a reliable and valid instrument for use in engineering graphics education. This assessment tool is being reintroduced as it has not been in print since 1972. As part of its original development, an extensive study was conducted to determine the reliability and validity of the BOVB and the instrument was determined to be psychometrically sound. This paper discusses the original development, a current pilot study with successful results, and presents the possibilities for future use within engineering graphics education.

Introduction

Methods of assessing students' spatial visualization abilities represent a substantial area of interest in the engineering graphics community. Recently research and discussion regarding the validity of current and commonly used assessments of spatial visualization ability have become a topic of keen interest. These studies and subsequent discourse have raised questions as to whether the most appropriate assessment is being used in engineering graphics courses to assess students' spatial visualization ability and if those assessments reflect the content being offered in engineering graphics courses. In short, have the currently used assessments run their course?

Much of the discussion of late has involved the Purdue Spatial Visualization Tests: Visualization of Rotations (PVST:R) although the Mental Rotations Test (MRT) and the Mental Cutting Test (MCT) have also received some, albeit lesser, attention. Research related to the construct validity of the PSVT:R have raised questions as to whether the test truly assesses mental rotation ability (Ernst, Williams, Clark, & Kelly, 2016). Another issue raised regarding the

PSVT:R is the ceiling effect and whether or not changes in students who scored high initially can be adequately assessed in post-testing (Goodrich, GreenHalgh, Lawanto, & Stewardson, 2012).

Aside from these issues, do these tests assess what we are explicitly teaching in engineering graphics courses? Research has shown that spatial ability is malleable with training (Uttal, Miller, & Newcombe, 2013; Sorby, 2009), but engineering graphics courses encompass larger curricular concepts. For instance, engineering graphics faculty has ranked the ability to make orthographic multiview sketches as the highest performance outcome for sketching engineering objects (Barr, 2012). Are we examining students' abilities and improvements in skills that are (a) explicitly taught and covered as part of the course and (b) representative of the explicit skills that may be needed for their future careers in engineering? Is there another visualization assessment that offers a response to the questions above, is directly related to the learning objectives of engineering graphics courses, limits the potential for a ceiling effect, and meets another key attribute of the PSVT:R, its availability for no-cost use?

The Biewald Orthographic Visualization Battery

In 1969, Edward Carl Biewald, as part of his dissertation, developed the *Visualization Test of Three Dimensional Orthographic Shape*. This test has been out of print since 1972 and, other than Biewald's original dissertation and some online references to the booklet in which the test was originally distributed, has fallen out of public consciousness. When this test was originally discussed as a potential assessment tool for research, copyright issues emerged as the publishing company had not been in business since 1972 and by all accounts, Dr. Biewald was deceased. After an exhaustive search, Dr. Biewald was located having retired in Connecticut. The authors of this paper sought and obtained permission directly from Dr. Biewald to reintroduce the test for new study and use in engineering graphics research and instruction (E.C. Biewald, personal communication, June 20, 2016).

The *Visualization Test of Three Dimensional Orthographic Shape* consists of 80 items contained in two separate forms (A & B) of 40 items each. The items contain two views of an orthographic projection and ask the participant to select the correct missing view from a choice of four or none of the views shown. Figure 1 shows a sample of three items from Forms A and B of the original *Visualization Test of Three Dimensional Orthographic Shape.*

The final version *Visualization Test of Three Dimensional Orthographic Shape* was given to a national sample of 508 secondary students from 15 schools in 13 states. The participating students were all enrolled in technical drawing courses and represented grades 9-12. This administration resulted in the following statistics: mean = 35.24 and standard deviation = 14.69. The original study also reported no statistical differences between males and females, $t(9) = .70$, $p = .499$.

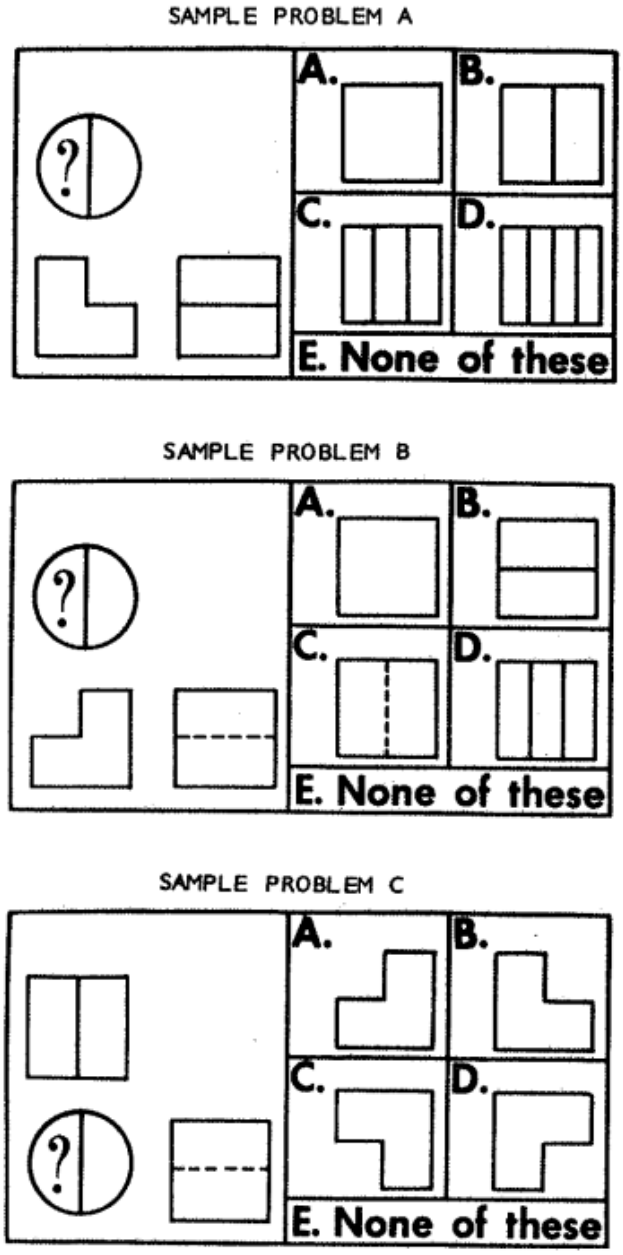

Figure 1*. Sample Items from the Original *Visualization Test of Three Dimensional Orthographic Shape.

As part of the original development of the test, there was extensive validation and reliability testing. This testing found the instrument to have exceptionally high reliability as determined by conducting a split-half reliability analysis (Spearman-Brown prediction formula) and determining the coefficient of internal consistency (ρ = .93). The *Visualization Test of Three*

Dimensional Orthographic Shape was also found to be a valid measure of an individual's level of achievement with respect to orthographic visualization. The *Visualization Test of Three Dimensional Orthographic Shape* was also determined to have a degree of difficulty suitable for secondary students at the time of the study and having statistical equivalence between both forms of the test.

As part of the reintroduction of this assessment, the authors of this paper deemed it appropriate to rename the *Visualization Test of Three Dimensional Orthographic Shape* to the *Biewald Orthographic Visualization Battery* (BOVB) in honor of the original developer and to ensure proper accreditation be given if/when adjustments are made to the assessment in the future.

Future Research

Biewald (1969) listed several suggestions for areas he identified as salient for further research. Relevant to the field of engineering graphics education are the need to assess and analyze the BOVB with college and university populations, the use of the assessment with participants, and correlations and covariance with other established visualization tests. The authors of this paper also suggest an examination into the usefulness of the test for pre- and post-assessment to evaluate improvement in orthographic visualization ability in engineering graphics courses. Further, a factor analysis with the aim of shortening the length of the test may also be appropriate as the full battery of 80 items consume the majority of a typical class period.

Toward these recommendations, a small pilot was conducted with university students in an introductory engineering graphics course. These students (n = 8) were incoming freshman engineering students participating in an early-entry summer program at NC State University. They were given a pre-test with Form A and a post-test with Form B. The pre-test results (M = 23.13, SD = 10.05) were not significantly different from the original sample (p = .18), although the authors acknowledge serious limitations with this small pilot study. The post-test results (M = 29.63, SD = 6.26) does not reveal statistically significant differences between the pre- and post-tests after ten days of instruction (p = .07), however, the 6.5 point difference in mean score represent a practical significance and demonstrate a clear need for further examination with a larger data set.

Conclusion

The *Biewald Orthographic Visualization Battery* represents a potential "new" method by which to assess engineering graphics students' visualization skills in a manner more appropriate to the skills directly taught in our courses. It has previously been shown to be a valid and reliable assessment of visualization skills without some of the limitations of other currently used and popular tests. The BOVB does not appear to be disadvantaged by a ceiling effect allowing for

more robust pre- and post-test analysis of skills attained. It is also offered for use freely for research and educational purposes which has been a large contributing factor for the use of tests such as the PSVT. While more research is needed, the authors of this paper feel the BOVB provides great potential for future use in engineering graphics research as the field continues to grow and evolve.

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