Material Dissemination of the Biewald Orthographic Visualization Battery

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Abstract

The Biewald Orthographic Visualization Battery (BOVB) represents a reliable instrument for use in engineering graphics education. Analysis of the BOVB indicates that there is evidence of predictive validity for academic outcomes when used as both a pre- and post-test. This paper provides the engineering graphics education community with an analysis of the instrument and the online location to access the assessment and the collaborative dataset intended for open access for researchers and practitioners.

Keywords: spatial visualization, engineering graphics, assessment, engineering education, persistence

Introduction

Spatial skills have long represented a major component in a variety of STEM fields and have been demonstrated to have predictive validity within engineering graphics (Sorby & Baartmans, 2000), a predictor of interest in, academic persistence, and career success within science, technology, engineering, and mathematics (STEM) disciplines (Wai, Lubinski, & Benbow, 2009; Torpey, 2013; Author), and recently, to have statistically significant associations with broad-scale score measures in English Language Arts (Rutherford, Karamarkovich, & Lee, 2018). STEM professionals tend to demonstrate skills significantly higher levels of spatial ability as students than their peers (Lubinski, 2010).

Several measurement instruments frequently used in engineering education include the Mental Rotations Test (MRT), the Mental Cutting Test (MCT), the Revised Minnesota Paper Form Board Test (RMPFBT), the Differential Aptitude Tests: Spatial Relations (DAT:SR), and the Purdue Spatial Visualization Tests: Visualization of Rotations (PVST:R; Author). It has also been demonstrated that spatial ability is malleable and can be improved with training (Uttal, Miller, & Newcombe, 2013; Sorby, 2009). The assessments listed above, as well as many

others not mentioned here, measure differing constructs within the broader scope of spatial ability. The Biewald Orthographic Visualization Battery (BOVB) adds to that list, an assessment that measures a student's ability to visualize three dimensional orthographic shape.

During a recent mid-year meeting of the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE), a "new" assessment of spatial ability was unveiled with the promise that it would be openly disseminated to the engineering as well as providing a digital platform from which researchers and educators can contribute to, and access, a repository of collaborative data for analysis and comparison.

The Biewald Orthographic Visualization Battery

The 80 items of the BOVB are contained in two separate forms, each with 40 items. These items contain two views of an orthographic projection and ask the participant to select the correct missing view from a collection of four possible answers or indicate that they do not see a solution in any of the four choices. Figure 1 shows a sample of three items from the BOVB.

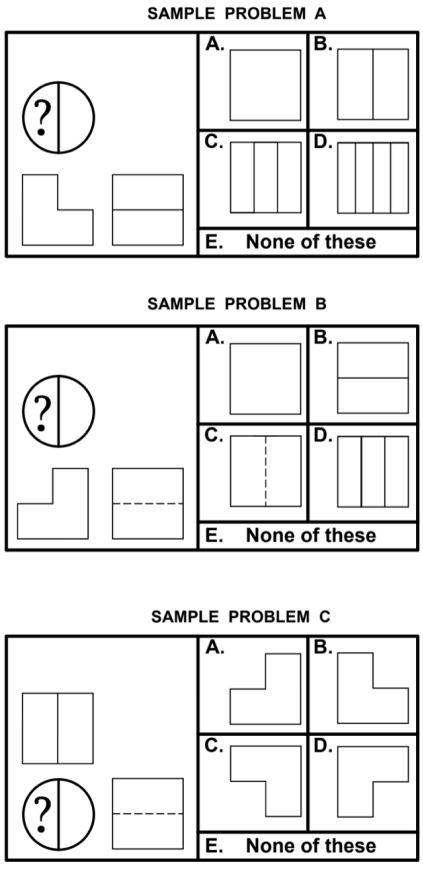

***Figure 1*. Sample Items from the Biewald Orthographic Visualization Battery.**

Correlational Analysis. Analysis of the BOVB taken by 146 engineering graphics undergraduate students showed statistically significant associations with final exam and course grades when the BOVB was used as a pre-test (Form A) and a post-test (Form B). The analysis also showed a strong statistically significant correlation between the pre- and post-test versions. The correlation coefficients are displayed in Table 1.

Table 1. Correlation Analysis for the Biewald Orthographic Visualization Battery

	BOVB Pre-Test	BOVB Post-Test	Final Exam Grade	Final Course Grade
BOVB Pre-Test	--			
BOVB Post-Test	0.72***	--		
Final Exam Grade	0.32***	0.37***	--	
Final Course Grade	0.25**	0.28**	0.69**	--

*Note.**p<.05; **p<.01;***p<.001

Reliability. The reliability of the BOVB scale was determined using Cronbach's alpha. Based on the stated threshold of .70 (Drost, 2011), the BOVB is reliable ($\alpha = .88$) with an average inter-item covariance of .03.

Means Testing. A t-test was conducted to compare the pre- and post-test mean scores for the engineering graphics students. The post-test scores (M = 25.10, SD = 7.91) on the BOVB was significantly higher than the pre-test scores (M = 19.09, SD = 8.02) by 6.02 points; $t(230) = 5.76$, $p < .001$. These results, combined with the significant correlation between the BOVB and final exam and course grade, provide evidence that the BOVB may be a potential predictor of academic performance in an introductory engineering graphics course.

Regression. A simple linear regression analysis was performed to examine whether the score (pre and post) on the BOVB was predictive of final exam scores. The final exam score was analyzed rather than the final course grade due to the strong positive correlation of the exam with course grade, the weaker correlation of the assessment to the final course grade than the final exam, and the exam being a more consistent measure of engineering graphics knowledge than the course grade with multiple independent factors such as homework completion that could not be controlled for in this study.

The score on the BOVB pre-test explains approximately 10% of the variance in the final exam scores, $R^2 = .10$, $F(1, 114) = 13.33$, $p < .001$, and is positively and

significantly related a student's final exam grade, b = .37, t(114) = 3.65, $p < .001$. For every item a student gets correct on the BOVB pre-test, we can expect them to score .37 percent higher than the mean final exam score. Similarly, the score on the BOVB post-test accounts for approximately 14% of the variance in the final exam scores, $R^2 = .14$, F(1, 114) = 18.03, $p < .001$, and is positively and significantly related a student's final exam grade, b = .43, t(114) = 4.25, $p < .001$. For every item a student gets correct on the BOVB post-test, we can expect them to score .43 percent higher than the mean final exam score.

Conclusion

The BOVB is a reintroduction of an instrument developed nearly 50 years ago that was seemingly lost to history. Analysis of the BOVB provides evidence that the use of the assessment in undergraduate introductory engineering graphics courses may have predictive validity for a student's score on the final exam and course grades. Although more study and analysis is warranted, the BOVB may be (in whole or in part) an appropriate instrument for the identification of students who may be struggling with the course content particularly within the context of orthographic projection. This intention of this paper and release of the BOVB to collect more data for analysis and share that data with the broader engineering graphics community to encourage collaboration among researchers and practitioners.

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 (*Biewald, 1969; 1971) to the *Biewald Orthographic Visualization Battery* in honor of the original developer and to ensure proper accreditation be given if/when adjustments are made to the assessment in the future. Dr. Biewald gave the authors explicit permission to reintroduce the assessment and make it publicly available. It will be publicly available for use as of the publication of this paper as part of the Connecting STEM Project.

To access the BOVB and the collaborative research dataset, visit the link below:

https://bovb.connectingstem.org

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