A Learner Profile Thematic Review of Introductory Engineering Design Graphics Students

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Abstract

This is a review of a thematic research strand that has focused on engineering design graphics and technology education students learning preferences, spatial abilities, strategies for learning, and motivation. The review employs a meta-analysis to collectively form a profile of student attributes and abilities of those engaged in engineering design graphics coursework. The conclusions given in this paper are formulated over a five year span using standardized instrumentation that include: 1) MSLQ (Motivated Strategies for Learning Questionnaire), 2) Purdue Spatial Visualization Test-Visualization of Rotations (PSVT) and the Mental-Rotations Test (MRT), and 3) VARK Questionnaire. Through this meta-analysis, kinesthetic learning preference, existing mental rotation ability, and moderate to high motivation are identified as learner attributes in engineering design graphics learners. The researchers propose that these factors should be considered in all curricula and course development related to engineering and technical graphics education.

Introduction

Over the years, many professionals in engineering graphics have researched ways to improve the pedagogical format from which they teach. Both in the United States and abroad, the focus is often on technology use, software integration, or enhanced assessment strategy (Mapson, Clark, & Ernst, 2008). Starting in 2007, the authors of this paper began examining the prospective improvement of introductory engineering and technical graphics methods, approaches, and content sequencing by carefully reviewing student background, interests, and overall educational understandings related to visual theory. The previously conducted thematic studies included the review of students, including those classified as at-risk of dropping out of engineering, in an introductory level post-secondary engineering/technical graphics course using standardized instruments to indicate student visual capabilities, preferred learning styles, and motivation. This is accomplished through administering three primary instruments; 1) MSLQ (Motivated Strategies for Learning Questionnaire), 2) Purdue Spatial Visualization Test-Visualization of Rotations (PSVT) and the Mental-Rotations Test (MRT), and 3) VARK Questionnaire. The information provided in this paper is a review and analysis of a collection of eight different studies the authors of this paper have conducted over a five year period (2007-2012) that relate directly to student profiles and what understandings and backgrounds each bring to an introductory course in engineering graphics. The data from these previously conducted analyses has been paired for the purposes of a Meta investigation to capture and overall learner profile of introductory engineering design graphics students. The discussion within this paper includes systemic qualitative reviews and conclusions that embrace the need for alternative assessment instruments, the need for kinesthetic hands-on learning throughout the curriculum, and the overall improve in instruments used in measuring visual capabilities in students. The data described in the paper holistically combines summary statistics found throughout the duration of the thematic study that relate to each standardized instrument used.

Method

From 2007 to 2012, the authors of this study have used a variety of instruments to review the learner profile of students taking introductory engineering graphics classes at the post-secondary level including MSLQ, PSVT/MRT, and VARK. The population has been students, mainly at the sophomore or junior level in college majoring in engineering or technology/engineering education in North Carolina at a major university. The courses have been taught by traditional methods, as well as in hybrid form using the Internet as a pedagogical tool (Ernst & Clark, 2008). The method used for this study was to merge summary statistics for the three standardized instruments used to collect data over the five-year period. All data comes from the same population mentioned above and collected by the researchers. Students that were defined as at-risk are included in the combined holistic data sets seen in the tables for this paper (Ernst, 2011). Note that at-risk college students for these studies were defined as those students with a GPA of less than 3.0 and unlikely to matriculate into an engineering or related discipline (Ernst & Clark 2012). The summary statistics were used to illustrate the three main discussion points made later in this paper by displaying the overall number of participates for each instrument, mean score with variance within each individual instrument, and standard deviation.

Results

The PSVT/MRT test has been used since the 1970's as a measure of student's capabilities to visualize in three-dimensions (3D). Many studies have been conducted using this popular test that relate to engineering graphics. The authors of this paper used the PSVT/MRT as one standardized instrument that professionals in the field would recognize and give a base for student's visual capabilities (Ernst & Clark, March 2012). Table 1 shows the combined summary for this instrument over the past five years. Note, with a mean of 22.73, this shows that the 91 participants who took this instrument satisfactorily answered 22 of the 30 PSVT/MRT questions correctly demonstrating overall visual proficiency.

Table 1. Purdue combined summary statistics

Instrument	n	Mean	Variance	Std. Dev.
Purdue Results	91	22.73	26.13	5.11

Neil Fleming, from the New Zealand education system, developed the VARK Questionnaire to better understand how individuals prefer to learn on visual (V), aural (A), read/write (R), and kinesthetic (K) education practices (Ernst & Clark, 2007). The researchers chose and used this instrument over the past five years to study the introductory engineering graphics student population because it measures preferred learning styles, not necessarily actual learning style. It is the belief of the researchers that if you have a clear learning style preference, then you are likely to adopt it as a primary channel of acquiring information (Ernst & Clark, 2008). Table 2 provides summary information associated with student responses on the VARK Questionnaire that spans three individual studies. Note, with the highest mean of .45 in Table 2 for the overall combined summary statistics for the VARK instruments in kinesthetic, therefore, it is assumed that students taking these introductory engineering graphics courses like the hands-on learning and working with both physical and visual models (Clark & Ernst, 2007).

Table 2. VARK combined summary statistics

Learning Preference	n	Mean	Variance	Std. Dev.
Visual Results	233	0.13	0.11	0.34
Aural Results	233	0.28	0.20	0.45
Reading Results	233	0.17	0.14	0.37
Kinesthetic Results	233	0.45	0.25	0.50
Multimodal Results	233	0.39	0.24	0.49

The Motivated Strategies for Learning Questionnaire (MSLQ) was designed to evaluate and assess post-secondary student's motivational orientation and the use of various learning strategies for college level course offerings (Clark, Ernst, & Scales, 2008). This instrument was used throughout the thematic study of introductory engineering graphic student's profiles to help link what motivates students in these classes to take courses in engineering graphics and learn the content. The fundamental engineering/technical graphics courses focused on basic visual literacy and the creation of solid models. This instrument was correlated with the other two instruments mentioned in this paper to better understand best practices for improving instruction (Clark, Ernst, & Scales, 2009). As seen in Table 3, the MSLQ combined summary statistical mean of 4.45, from a Likert scale of 1 to 7, gives the overall understanding that students are moderately motivated in these courses.

Table 3. MSLQ combined summary statistics

Instrument	n	Mean	Variance	Std. Dev.
MSLQ Results	245	4.45	2.53	1.56

Discussion

This study is an overview formed through a meta-analysis of the thematic research that identifies the attitudes, attributes, and abilities of engineering graphics students over a five-year time span with a more inclusive and broader snap-shot of students that take introductory engineering graphics related courses. Given the qualitative analysis of the combined statistics on standardized instruments mentioned in the results section and the outcomes/conclusions associated with the eight studies related to this thematic research, the following are major discussion points to date. First, the research shows that more targeted assessment instruments need to be created that further distinguish among variables of introductory engineering design graphics students pertaining to motivation, learning strategy, learning preference and spatial visualization. These new or improved instruments need to focus on the unique nature of what the engineering design graphics discipline has to offer with a combined approach to improve overall student performance both in and out of the classroom. Next, and to the authors the most significant, it is suggested that the tactile nature of the digital interface cannot be discounted. This suggestion gives credence to the reinforcement of physical model creation throughout the curriculum. One major finding on the last five years in student learning preferences has been the issue of kinesthetic over visualization. McGrath and Brown (2005) indicate that visual learners are engaged and learning is enhanced through traditional engineering design graphics presentation methods, but this thematic research shows that students consider themselves to be largely hands-on learners or multimodal, not exclusively visual. The data from these previously conducted analyses has been paired for the purposes of a meta investigation to capture and overall learner profile of introductory engineering design graphics students. More research is needed in this area. Finally, this thematic research base shows that on average, students taking introductory engineering graphic courses have a level of proficiency in visualization, but additional steps need to be taken to improve their abilities. New or improved visualization instruments that use contemporary items or processes could help students further articulate what they are seeing through the process of visual thinking.

In conclusion, the combined purpose of this meta-analysis is to identify existing student abilities, preferences, motivations, and applied strategies for learning. Collectively, from further analysis of these eight studies, it has been established that introduction to engineering design graphics students predominately prefer kinesthetic learning while relying on their visual and mental rotation capabilities. Instructors need to consider these preferential elements when designing curriculum and activities for the classroom. Similarly, considerations to support student engagement and ultimately improvement of student motivation must be central factors in course design.

References

Ernst, J.V. & Clark, A.C. (March 2012). Spatial acuity in engineering design graphics. Proceedings of the Council on Technology and Engineering Teacher Education of the International Technology and Engineering Educators Association Annual Conference, Long Beach, CA.

Ernst, J.V. (2011). At-risk learner preference in engineering/technical graphics: An exploratory study. *Engineering Design Graphics Journal, 75*(3) 7-18.

Ernst, J.V. and Clark, A.C.(June 2012). At-risk visual performance and motivation in introductory engineering design graphics. Refereed proceedings of the American Society for Engineering Education Annual Conference and Exposition, San Antonio, TX.

Ernst, J.V., Clark, A.C., & Scales, A.Y. (June 2009). A comparison of the attitudes and motivation of students in an introductory technical graphics course: A mixed methods analysis. Refereed proceedings of the American Society for Engineering Education Annual Conference and Exposition, Austin, TX.

Clark, A.C., Ernst, J.V. & Scales, A.Y. (June 2008). The attitudes and opinions of students toward technical graphics: Preliminary survey results. Refereed Published Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Pittsburgh, PA.

Clark, A.C. and Ernst, J.V. (November 2007). Preferred learning style assessment of graphic communications students. Published Refereed Proceedings of the American Society for Engineering Education Mid-Year Technical Conference, Virginia Beach, VA.

Ernst, J.V. and Clark, A.C. (2007). Effects of instructional presentation on dominant preferred learning styles. *North Carolina Council on Technology Teacher Education*, 9(1) 45-57.

Ernst, J.V. & Clark, A.C. (2008). Students' preferred learning styles in graphic communications. *Engineering Design Graphics Journal, 72*(1) 9-18.

Ernst, J.V. & Clark, A.C. (Spring, 2008). Differences in perception between male and female students when studying information and communication technology. *Visual Communication Journal*, 21-26.

Mapson. K.H., Clark, A.C., & Ernst, J.V. (2008). VARK: An introspective look at introductory graphic communications courses at North Carolina State University. *North Carolina Council on Technology Teacher Education*, 10(1) 20-29.

McGrath, M.B., & Brown, J.R. (2005). "Visual learning for science and engineering," *Computer Graphics and Applications, IEEE* , 25(5), p.56-63.