fall 2011

volume 75 number 3

THE ENGINEERING DESIGN GRAPHICS Journal

Engineering Design Graphics Journal (EDGJ)
Fall 2011, Vol. 75, No. 3
http://www.edgj.org

ISSN: 1949-9167

Table of Contents

Copyright 2011
ISSN: 1949-9167

Editorial Board, Advisory Board, and Review Board

Online Distribution

The online EDGJ is a reality as a result of support provided by East Carolina University; Biwu Yang, Research & Development, ECU Academic Outreach; Blake Smith, ECU Academic Outreach; and Cody Skidmore, Duke University Help Desk Specialist and the Journal's Web Production Manager.

Engineering Design Graphics Journal (EDGJ)
Fall 2011, Vol. 75, No. 3
http://www.edgj.org

ISSN: 1949-9167

Message from the Chair

Aaron C. Clark
North Carolina State University

Welcome to yet another busy year for the Engineering Design Graphics Division! Over the past years, the leadership of the division has worked together to provide quality experiences for both new and old (in years of service only) members. This coming year will be no exception with many opportunities to be active within our profession. Our first Mid-Year Meeting of 2012 will start the New Year off in Galveston, Texas, and in June we will have our annual ASEE conference in San Antonio. Two international events related to our field that will take place in 2012 includes the International Society for Geometry & Graphics conference in Montreal, Canada in August and our division's Mid-Year Conference to be held in Limerick, Ireland in November 2012, our first overseas adventure. These different meetings allow professionals in engineering design graphics to come together, make new friends, develop professionally, and share research from the field as we strive to constantly improve ourselves, the students we serve, and our profession of engineering design graphics. Please take time to come and participate in as many of these different venues as you can because it's the information presented in settings like these that help formulate the content we see in our Engineering Design Graphics Journal and other journals related to our field as well as indicate directions our profession is taking both nationally and internationally. Please help "set the stage" for the future of our field and division.

On a personal note, I would like to thank Tim Sexton for his leadership this past year as Chair as well as all members of the executive board for the great work accomplished under Tim's leadership. We have joining our executive board the Vice Chair elect Nancy Study, who has already started her position working on scholarship recipients for our January Mid-Year meeting in Texas. Also, Nicholas Bertozzi was re-elected as Director of Communications, we thank Nick for the wonderful job he has done for the division. In closing, I would like make two charges to the members. First, plan to share your work through our refereed journal so that we can improve our profession with new knowledge and understandings. Second, please promote our division and help us grow in membership this coming year. Reach out to other colleagues here in the United States and other countries in engineering, technology, design, and education and personally invite each to become active members of our Engineering Design Graphics Division.

Professionally yours in service,

Aaron C. Clark, DTE
Chair

Engineering Design Graphics Journal (EDGJ)
Fall 2011, Vol. 75, No. 3
http://www.edgj.org

ISSN: 1949-9167

Message from the Editor

Robert A. Chin
East Carolina University

Almost 20 years ago, the American Psychological Association (APA) published Ethical Principles of Psychologists and Code of Conduct—see http://www.apa.org/ethics/code/index.aspx. Because of the manner in which the Division's scholarly work is now disseminated, it would behoove us all who share our research findings and the results of our creative efforts to familiarize ourselves with this guidance. Special attention should be given to the paragraphs in Section 8, Research and Publication, which deal with the publication of research findings. Authors are also encouraged to study the Publication Manual of the American Psychological Association: specifically pages 12-17.

At one time, because the Mid-Year conference proceedings were not widely disseminated—only among the Mid-Year attendees, authors of proceedings papers were encouraged to submit their Mid-Year papers for publication in the Journal. Since the 60^{th} Mid-Year (2005), however, our proceedings have been posted to the division site annually.

As all of you are probably aware, one of the Journal's fixtures, Associate Editor, Nancy Study, ascended to the Division's Vice-Chair. She began her service as the Associate Editor with volume 70 number 3 while the Journal was under the editorship of my predecessor, La Verne Abe Harris. Moreover, Nancy was instrumental in transitioning the Journal to its present online only format. Many thanks, Nancy, for your years of dedicated service to the Journal. All the best to you as our Division's new Vice-Chair.

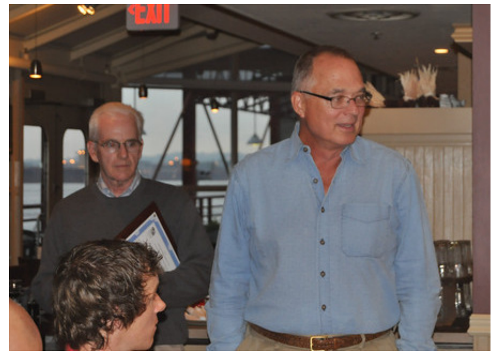
Assuming Nancy's responsibilities is Amy "AJ" Hamlin, Lecturer, Department of General Engineering, Michigan Technological University. In anticipation of her departure, Nancy's has been grooming AJ to ensure the transition takes place seamlessly, the strong working relationship between the Associate Editor and reviewers, and the strong working relationship between the Associate Editor and the authors is sustained. We're all looking forward to working with you AJ.

Finally, I'd like to acknowledge Theodore "Ted" Branoff for his years of quiet service to the Division as its unofficial photographer. I will readily admit I have, as the EDGJ Editor, used his work without proper attribution. In an attempt to acknowledge his work—past and future, I've made him the Journal's photographer (see http://www.edgj.org/index.php/EDGJ/about/editorialTeam). Thank you Ted.

ISSN: 1949-9167

The Distinguished Service Award

The 2011 Distinguished Service Award (DSA) recipient is Michael D. Stewart of the Georgia Institute of Technology. The award is the highest award of merit given by the Engineering Design Graphics Division. It recognizes the significant contributions of the recipient to the Division in terms of leadership, authorship, or support.



[1]

The awardee is recognized with a framed citation or plaque, which is presented by the Division Chair or their delegate at the Annual Conference Awards Banquet. Following the presentation, the recipient may address those assembled.

[2]

The award description can be found at
http://edgd.asee.org/awards/dsa/index.htm

A complete list of awardees list can be found at
http://edgd.asee.org/awards/dsa/awardees.htm

[3]

[1] EDGD Chair, Timothy Sexton (l) and Jon Duff (r), 2004 DSA recipient, introducing the 2011 DSA recipient. [2] DSA recipient, Michael D. Steward (l), accepting the DSA; EDGD Chair, Timothy Sexton (c); and Jon Duff (r) presenting the DSA plaque. [3] Steward being congratulated by Duff.

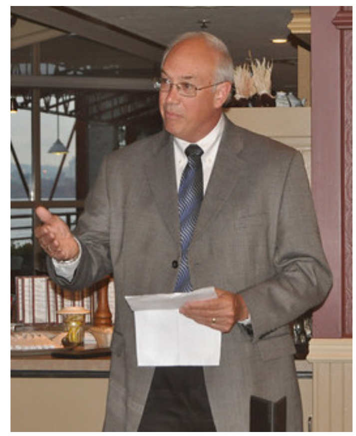
Photos by Theodore Branoff

Engineering Design Graphics Journal (EDGJ)
Fall 2011, Vol. 75, No. 3
http://www.edgj.org

ISSN: 1949-9167

Michael D. Stewart's DSA Acceptance Remarks
ASEE Annual Conference
Vancouver, BC, Canada, June 28, 2011

Thank You.



I accept this Distinguished Service Award with a humble and grateful heart. I also accept it on behalf of my wife and family. I would like to thank my wife, Julie and our 6 children, Jennifer, Michelle, Greg, Tabitha, Janell and Brandon for their love, support and encouragement over the years that I have been active in this Division and for their sacrifices during my career.

I would like to thank all of the many EDGD members who over the years have welcomed me into this Division and allowed me to serve this Division through a number of positions which I have been fortunate to have served. I plan to continue my service to the Division as a program chair for the ASEE conference in Atlanta in 2013 and invite all of you to plan now to attend that great event in Hotlanta!!

I have grown so much as a result of what I have learned from the many members of this Division over the last 26 years. My first attendance was at Purdue and I was so amazed at all those people I saw at my first Midyear. As the result of meeting many of the members over these past years I have been fortunate to be mentored by many of the past DSA and Division officers. I have learned so much from so many.

I am sure that I would certainly not be at this point in my life if it had not been for those members who have helped me during these many years. You who are here, thank you, you know who you are.

I would like to take this opportunity to thank some people who have especially made a difference in my career. Alida Hall, my high school principal that told me I needed to move on from teaching in junior high and high school. For the University of South Dakota at Springfield for taking a chance on me and hiring me with no experience and only a Bachelor's degree. To Dean Walter Thomas who was my greatest supporter and provider for my many years at the University of Arkansas. Finally to the Chair and Administration of Mechanical Engineering at Georgia Tech who accepted me for what I am and not for what I did not have or wasn't and for supporting me and providing me with the greatest teaching position I could ever imagine having in my lifetime.

  ISSN: 1949-9167

I also would be remiss if I did not thank the many people at Autodesk who since 1984 I have had the privilege of working for in learning and training. Many of whom have been very active in our Division, especially Jim Melloy and our own dear departed Rodger Payne.

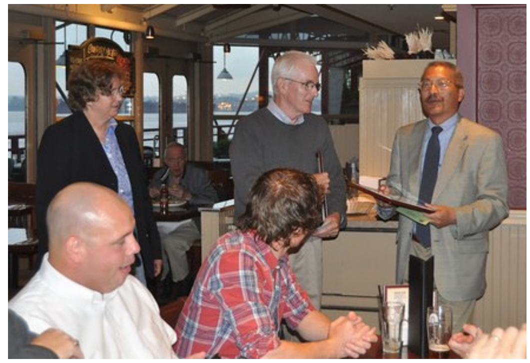
So thank you members of this Division for this glorious award, I am humbled by the support you have given me and look forward to continuing to work in service to all of you in the years to come.

Michael D. Stewart

ISSN: 1949-9167

The Editor's Award

The 2010 Editor's Award awardees are Holy K. Ault of Worcester Polytechnic Institute and Samuel John of the Polytechnic of Namibia for their paper entitled Assessing and Enhancing Visualization Skills of Engineering Students in Africa: A Comparative Study. Their paper was published in volume 74, number 2 of the Journal and can be found at: http://www.edgj.org/index.php/EDGJ/article/view/197/175



[1]

The Editor's Award was established to recognize the outstanding paper published in the previous volume of the Engineering Design Graphics Journal. The recognition includes a framed citation and a cash award and is presented during the following Annual Conference.

[2]

The award description can be found at http://edgd.asee.org/awards/editors/index.htm

A complete list of awardees list can be found at http://edgd.asee.org/awards/editors/awardees.htm

[1] Award recipient Holly K. Ault (l), EDGD Chair Timothy Sexton (c), and EDGD Director of Publications and EDGJ Editor Robert A. Chin (r) reading the citation. [2] Award recipient Holly K. Ault, EDGD Chair Timothy Sexton, and EDGD Director of Publications and EDGJ Editor Robert A. Chin presenting the framed citation to Ault.

Photos by Theodore Branoff

Engineering Design Graphics Journal (EDGJ)
Fall 2011, Vol. 75, No. 3
http://www.edgj.org

ISSN: 1949-9167

Officer Nominees

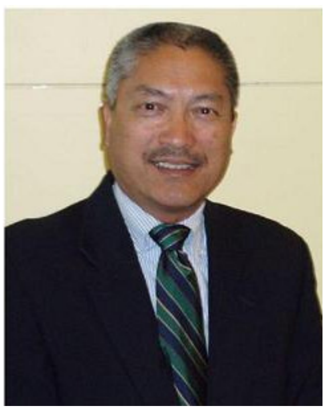
According to Article IV: Elections and Succession of Officers, Section 1, paragraph 1d of the Division by-laws (http://edgd.asee.org/aboutus/edgdbylaws.htm), not later than February 15, and returnable before March 15, the Secretary-Treasurer shall mail to each member of record (as provided by the Journal Circulation Manager-Treasurer) of the Division a ballot bearing the slate submitted by the Nominating Committee together with additional names presented by petition. A candidate receiving the largest number of votes for the office sought shall be declared elected. The ballot shall be designed to facilitate return mailing and bear the name and address of the chair of the Elections Committee, the Division Vice-Chair.

The Division members that follow comprise the slate of candidates.

Dennis Lieu
For Vice-Chair
Dennis Lieu received his BS, MS and D.Eng. in Mechanical Engineering from UC Berkeley in 1977, 1978 and 1982, respectively. After working for six years as a design engineer in industry, he returned to UC Berkeley as a member of its faculty. Prof. Lieu has taught engineering graphics at Berkeley for over 20 years, and has been a member of EDGD for 18 years. He was the host of the EDGD Midyear Conference in Berkeley in 2002 and again in 2009. He is the author or co-author of numerous articles on engineering graphics education, and is co-author (with Sheryl Sorby) of *Visualization, Modeling, and Graphics for Engineering Design*, published by Cengage. His research interests are in the design of electro-mechanical actuators and the design of sports equipment. He is a member of Tau Beta Pi, Pi Tau Sigma, and Phi Beta Kappa, and is a recipient of the University of California Distinguished Teaching Award. In 2008, he was awarded the Orthogonal Medal by North Carolina State University for his contributions to engineering graphics education. If elected as an officer in EDGD, his goal would be to expand the size and scope of the Division to include non-traditional areas.

Copyright 2011
ISSN: 1949-9167

Norma L. Veurink
For Secretary/Treasurer
Norma L. Veurink is a Senior Lecturer in the Engineering Fundamentals Department at Michigan Technological University where she teaches introductory engineering courses which include engineering graphics. She teaches a spatial visualization course designed for engineering students with poor spatial visualization skills. Ms. Veurink manages several summer programs that introduce middle and high school students to engineering. She is active in the American Society for Engineering Education and the American Society of Civil Engineers. Her research interests include spatial visualization, engineering education and first-year programs.



Robert A. Chin
For Director of Publications
Robert A. “Bob” Chin is a Professor in the Department of Technology Systems, College of Technology and Computer Science at East Carolina University, where he’s taught since 1986. In addition, he is a full member of the East Carolina University and Indiana State University graduate faculties. Chin received his PhD from the University of Maryland, College Park; MAE from Ball State University; BA from the University of Northern Colorado, and AAS from the Community College of the Air Force. Before joining the ECU faculty, he was on the College of Education faculty at the University of Maryland, College Park. Chin is an active member of ASEE. He has presented numerous papers at annual conferences, FIE, mid-year conferences/meetings, and at ASEE’s Southeastern Section meetings. He has had numerous journal articles published including several in the Engineering Design Graphics Journal. He has served as the Engineering Design Graphics Division's Director of Programs, as annual and mid-year conference/meeting program chair and he has served as a review board member for the EDGJ. Chin has been a program chair for the Southeastern Section Meeting and has served as the EDGD's Vice-Chair and Chair and as the Instructional Unit's Secretary, Vice-Chair, and Chair. He is the current EDGD Director of Publications and is the current EDGJ Editor.

Engineering Design Graphics Journal (EDGJ)
Fall 2011, Vol. 75, No. 3
http://www.edgj.org

ISSN: 1949-9167

At-Risk Learner Preference in Engineering/Technical Graphics: An Exploratory Study

Jeremy V. Ernst
Virginia Tech

Abstract

This exploratory study investigated learner preferences of secondary Career and Technical Education (CTE) Engineering/Technical Graphics students using the VARK Questionnaire. The VARK Questionnaire is an instrument that assists in determining students' dominant preferred learning styles, whether visual, aural, reading, or kinesthetic. This study identifies learner preferences of high school student participants and examines learner preference differences among at-risk students and students not categorized as at-risk. Results of this study highlight an identifiable preference toward kinesthetic learning for at-risk and not at-risk participants. Through statistical evaluation and analysis, common learner preferences among at-risk participants and not at-risk participants were identified. Results and findings of this study present the possibility that instruction, practice, and implementation can be uniformly addressed in CTE Engineering/Technical Graphics while maintaining favored means of learning for at-risk and not at-risk students alike.

Introduction

Invariable differences exist among learners in preferences of learning and in the method that students process, comprehend, and retain information (Goorha & Mohan, 2010). Educational research has recognized/identified a collection of factors that account for what has been determined to consist of a representative portion of initial variability in student learning processes and outcomes (Reid, 1987). Chief among these factors are learning styles and learner preferences. Further, Reid (1987) notes that learning styles and preferences are identifiable indicators of how students not only perceive learning but how they respond to it. According to the work of Berg and Wacker (as cited in Windsor, Piche, & Locke, 1994), motivating and engaging instructional practice and activity increases the responsiveness of learners. Mann identifies from a set of investigations through the participation hypothesis that the more involved students are in the process of learning, the more they learn (as cited in Hancock, 1992). There are several ways to identify instructional and activity preference, including observation of learners' behavior and/or assessment. Windsor, Piche, and Locke (1994) note that learner preferred items tend to be reinforcing, highlighting the investigation of learner preferences as a viable method in determining potential reinforcers.

In the work of Spratt (1999), preferred learning activities are identified as focusing on three primary areas: 1) the learners' opinions of their preferences, 2) teachers' preferences, and 3) comparisons of learners' and teachers' preferences. This categorization lends instructional identification partially to the students and in some measure to the teachers, resulting in a fashioned approach that not only considers student reinforcement methods, but also the teachers' preferences, wishes, and strengths. Gellevij, Van Der Meij, Jong, and Pieters (2002), through their cognitive load and dual coding theory study, determine that multimodal instruction leads to better performance and learner outcomes than unimodal instructional approaches. Ausburn and Brown (2006) conclude from their learning patterns research that Career and Technical Education (CTE) students have a learning strategy distribution that differs from the general academic population. The Ausburn and Brown findings uncover identifiable learner demands and needs that possess dissimilarities with current methods employed in traditional educational structures and environments. Provided the unique learner that CTE invites, what are the learner preferences and are those different for subsets of CTE students?

Learner preference categorical classifications are only one of the identifiable distinctions among CTE students. Subsets of CTE students not only pertain to visual, aural, reading, and kinesthetic classifications, but observed factors where interventions can be established to promote successes in educational environments. One such subset is students identified as at-risk. An inclusive definition of at-risk students is offered by Sagor and Cox (2004, p.1) as "any child who is unlikely to graduate on schedule with both the skills and self-esteem necessary to exercise meaningful options in the areas of work, leisure, culture, civic affairs, and inter/intra-personal relationships." Intervention strategies for at-risk students range from academic attainment goals, social goals, and vocational goals to self-esteem, self-management, and learner motivations (Kennedy & Morton, 1999). In many instances, research has yet to be incorporated to inform educational approaches concerning classroom alteration and teaching practice (Day, 2002).

Sequencing and instructional determinations are central to receptiveness and engagement for students. The receptivity and approachability of educational sequencing and determinations are largely based on relevance, preferential methods/modes, and overall appeal (Spratt, 1999; Gellevij, Van Der Meij, Jong, & Pieters, 2002). Following the sequencing work of Spratt (1999) and the instructional determinations of Gellevij, Van Der Meij, Jong, and Pieters (2002), an investigation of student learner preferences was formed for CTE Engineering/Technical Drafting high school students. More specifically, this examination focused on differences in categorical preferences of learning among not at-risk CTE students and CTE students categorized as at-risk.

Research Questions and Hypotheses

The work of Ausburn and Brown (2006) identifies that CTE students' strategy of learning possesses unique characteristics to the strategy of learning for non-CTE students. Therefore, the primary purpose of this study was to highlight the overall categorical preference of learning for students enrolled in CTE Engineering/Technical Drafting. Additionally, this study investigates learner preference differences between students identified as at-risk and students who are not identified as at-risk in CTE Engineering/Technical Drafting. The following questions guided this study:

1. What are the learner preferences of Engineering/Technical Drafting students?
2. Do Engineering/Technical Drafting students categorized as at-risk have learner preference differences from Engineering/Technical Drafting students not categorized as at-risk?

Research Question 1 was evaluated through providing a holistic learner preference descriptive categorization based on the standardized breakdown strategy of the utilized instrumentation. Hypotheses were derived to provide specific evaluation of Research Question 2: a) There is no difference in visual learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk. b) There is no difference in aural learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk. c) There is no difference in reading learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk. d) There is no difference in kinesthetic learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk.

Engineering/Technical Graphics in NC

Engineering/Technical Graphics is a specific course offering within the CTE area of Trade and Industrial Education. The Engineering/Technical Graphics curricular offering is based on the state of North Carolina's standardized contact hour structure (a range of 135-180 hours of instruction). According to the North Carolina Department of Instruction's (2005) course blueprint catalog, this course establishes the application of graphics tools obligatory to the development of communication graphics that assist in analyzing and understanding concepts found in engineering, science, and mathematics. The six topical units of study for the Engineering/Technical Graphics course include:

1) 3D Modeling
2) Manufacturing Processes
3) Dimensioning and Conventional Tolerancing
4) Sectional Views
5) Auxiliary Views
6) Pattern Development

The intent of the 3D Modeling unit is to implement 3D Computer Aided Drafting (CAD) concepts to complete design solutions. Inventor, ProDesktop, SolidWorks, or SolidEdge are applications widely used by engineering firms that produce 3D part modeling through constraint-based or parametric modeling (North Carolina Department of Public Instruction, 2005). The purpose of the manufacturing processes unit is to offer students information and process skill associated with industrial mechanical drawing. The Dimensioning and Conventional Tolerancing unit introduces methods and practices used in solid modeling to specify object height, width, clearance, and tolerance dimensioning. Additionally, assembly considerations are addressed associated with modernized industry and interchangeable solutions. The Sectional Views unit demonstrates interior detail or space by means of selected object views and external features. Cutaway views, sectional views, and cross sectional views are also discussed and created in the Sectional Views unit using CAD applications. The purpose of the Auxiliary Views unit is to present the basic concepts and features of orthographic, angled surface, and inclined surface generation and composition in multiview works. The Pattern Development unit aids students' manufacturing-based understandings and design abilities in material formation such as objects formed from flat materials.

At-Risk Classification

Students identified as at-risk in the state of North Carolina are eligible for services provided by each school district and/or each local education agency to organize equivalent contact to recruitment, enrollment, and placement activities (Hatch, 2009). These auxiliary service options are fundamental to fully inclusive participation of disadvantaged and disabled students in CTE programs. Students in grades 7-12 eligible for coordination services must meet one or more of the following categorical identifiers: Students identified with disabilities, students from economically disadvantaged families, students preparing for nontraditional training and employment, students with limited English proficiency, students who are single parents or are currently pregnant (Hatch, 2009). Students with disabilities classification are previously determined by local education agency referral, evaluation, and determination of categorical disability. Hatch (2009) further identifies that economically disadvantaged criteria for coordination services eligibility is based on government aid to families, food vouchers, free or reduced-price school lunch, identified as a low-income family based on the Department of Health and Human Services Poverty Guidelines, or is a foster child based on abuse, poverty, or neglect. Students preparing for nontraditional training and employment are those enrolled in CTE and have aspirations of pursuing a career outside of the programmatic offerings in an underrepresented occupation. Students with limited proficiency in reading, writing, and/or speaking the English language are included in at-risk determination. Finally, students who are expectant mothers or are single individuals with at least one child also are eligible for coordination services (Hatch, 2009).

Instrumentation

The VARK Questionnaire is employed in this study to evaluate learning preferences of secondary Engineering/Technical Graphics students. The questionnaire is used in an effort to determine students' dominant preferred learning styles, whether visual, aural, reading, or kinesthetic. Neil Fleming from Lincoln University, New Zealand, developed the VARK Questionnaire. Fleming's VARK design diverges from many learning style instruments in that its foremost objective is to be consultative rather than prognostic. Fleming (1995) identifies visual learners, coded with "V" by the VARK Questionnaire, as those who prefer information to appear in the form of graphs, charts, and flow diagrams. Speech is recognized through hearing and is consequently coded as aural (A) by the VARK questionnaire. The outcomes for other respondents could reveal a partiality for accessing information from written words. Respondents with these questionnaire outcomes are coded reading (R) since they use reading as their primary preference for information acquisition. The final group in the four component typology is composed of learners who would rather experience learning by using all their senses, including touch, hearing, smell, taste and sight. This group is commonly depicted in literature as kinesthetic (K) learners. They desire tangible experiences in their learning. The VARK Questionnaire is composed of 16 questions that assist in identifying preferred learning styles. "The questionnaire is deliberately kept short in order to prevent student survey fatigue. It also tries to encourage respondents to reflect and answer from within their experience rather than from hypothetical situations (Fleming & Baume, 2006, p.5)." Participants are directed to choose the answer that best explains their preference (Fleming, 2006). Multiple answers can be selected for each question, as participants may have more than one preference for each inquiry. After completion of the questionnaire, students' preferences are output in the form of modality scores.

Leite, Sviniki, and Shi (2010) conclude through a VARK validation study that the estimates for the scores of the visual, aural, read/write, and kinesthetic subscales are determined to be reliable based on results of factor loadings and factor correlations (confirmatory factor analysis). The evidence of validity of the VARK scores with respect to dimensionality and reliability, found in the study, support the use of the VARK Questionnaire for the purposes of this exploratory descriptive study. However, Leite, Sviniki, and Shi caution against its use a diagnostic tool for learning style instead of summarized learner preference.

Data Collection

The method and strategy employed for this investigation is best categorized as an exploratory study with a descriptive research design. The study utilizes a questionnaire to collect targeted information that describes existing conditions by making comparisons among a structured research sample. The student participants for this study were selected based on enrollment in the North Carolina CTE offering of Engineering/Technical Graphics. Eight Engineering/Technical Graphics sections taught by two instructors agreed to participate in this study. VARK instrument access was provided to both study sites, administered by instructors, and submitted electronically by the students in the third quarter of a single semester course. Student VARK information was uniquely alphanumerically veiled through an online data collection system to assist in participant confidentiality. The student participant learner preference information was electronically accessed, coded for at-risk and not at-risk categorization based on the alphanumeric coding, and was transposed in order to be imported into software for

ISSN: 1949-9167

statistical analysis. Frequency calculations to evaluate the first research question and contingency tables to evaluate the second research question were formed into outputs based on VARK student learner preference information.

The frequency tabulation was conducted in order to provide an indication of learning preferences for all participants. The contingency tables for visual, aural, reading, and kinesthetic learner preferences provide categorical learner (at-risk or not at-risk) numbers of students based on the VARK Questionnaire identifier strategy. The customary method for statistical examination of contingency tables is to apply the chi-square statistic to each cell of the table (Kirkman, 1996). Kirkman further identifies that the selection of the chi-square computation may produce erratic outputs if any single cell results in an expected value of less than five. Based on the sample of this study, the chi-square statistic was determined to be a less reliable option. Therefore, the four hypotheses of statistical differences between the two sample subgroups were assessed with the Fisher's exact test. The Fisher exact test is most commonly applied to evaluation of a hypothesis with data framed in a 2x2 contingency table where chi-square assumptions are not individually met (Sheskin, 2007). The null hypotheses are evaluated based on the probability of determining a collection of "observed frequencies even more extreme" than the set summarized in the contingency tables (Sheskin, 2007 p.633).

Results and Findings

Of the 132 participants, 25 were determined to be multimodal learners by the VARK Questionnaire. Multimodal learners are identified through the questionnaire as having more than one distinct learner preference. For the purposes of the frequency and relative frequency tabulations in Table 1, the 25 respondents were included in both category counts to identify the inclusive extent of the questionnaire determinations. The Engineering/Technical Graphics students as a whole prefer kinesthetic learning (51.5 percent of the participants), followed by aural learning (37.1 percent of the participants). The frequency table (Table 1) provides an indication of learning preferences for all participants. However, contingency tables were also generated to identify frequencies for at-risk and not at-risk students for visual, aural, reading, and kinesthetic preferences.

Table 1. Frequency table for engineering/technical graphics students

Preference	Frequency	Relative Frequency
V	17	0.129
A	49	0.371
R	23	0.174
K	68	0.515

Once again, 25 of the participants were determined to be multimodal learners by the VARK Questionnaire. For the purposes of the contingency table tabulations in Table 2, Table 3, Table 4, and Table 5, the 25 respondents were included in both category counts. Five of the multimodal learners were at-risk student participants and 20 of the multimodal learners were student participants not identified as at-risk. The Fisher exact test was used to evaluate the four study hypotheses. Table 2, categorizes visual outcomes and examines visual preferences for at-risk and not at-risk student participants (Hypothesis A). Table 3, categorizes aural outcomes and examines aural preferences for at-risk and not at-risk student participants (Hypothesis B). Table 4, categorizes reading outcomes and examines reading preferences for at-risk and not at-risk student participants (Hypothesis C). Table 5, categorizes kinesthetic outcomes and examines kinesthetic preferences for at-risk and not at-risk student participants (Hypothesis D).

Three at-risk student participants and 14 student participants that are not at-risk were determined to prefer visual learning. Hypothesis A: There is no difference in visual learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk is evaluated with the Fisher exact test in Table 2. The visual outcome ("probability of obtaining a set of observed frequencies equal to or more extreme than the set obtained in the study, (Sheskin, 2007 p.634).") is P = 0.558. The previously specified study value of α is 0.05, not detecting a more extreme set of visual learner preferences for study participants at-risk and not at-risk.

Table 2. Contingency table and Fisher exact test results for visual preference

Visual outcome: $P = 0.558$			
	Not visual	Visual	Row sums
At-risk	32	3	35
Not at-risk	83	14	97
Column sums	115	17	132

As shown in Table 3, 12 at-risk student participants and 37 student participants that are not at-risk were determined to prefer aural learning. Hypothesis B: There is no difference in aural learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk is evaluated with the Fisher exact test in Table 3. The aural outcome is P = 0.837. Again, at $\alpha = 0.05$, evaluation of the aural outcome did not identify a more extreme set of aural learner preferences for at-risk and not at-risk study participants.

Table 3. Contingency table and Fisher exact test results for aural preference

Aural outcome: $P = 0.837$			
	Not aural	Aural	Row sums
At-risk	23	12	35
Not at-risk	60	37	97
Column sums	83	49	132

ISSN: 1949-9167

Five at-risk student participants and 18 student participants that are not at-risk were determined to prefer reading-based learning (Table 4). Hypothesis C: There is no difference in reading learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk was evaluated with the Fisher exact test and the reading outcome was P = 0.795. At $\alpha = 0.05$, evaluation of the reading outcome did not identify a more extreme set of reading learner preferences for study participants at-risk and not at-risk.

Table 4. Contingency table and Fisher exact test results for reading preference

Reading outcome: *P* = 0.795			
	Not reading	Reading	Row sums
At-risk	30	5	35
Not at-risk	79	18	97
Column sums	109	23	132

Twenty at-risk student participants and 48 student participants that are not at-risk were determined to prefer kinesthetic learning. Hypothesis D: There is no difference in kinesthetic learner preference for Engineering/Technical Drafting students categorized as at-risk and Engineering/Technical Drafting students not categorized as at-risk is evaluated with the Fisher exact test in Table 5. The kinesthetic outcome is P = 0.554. Once again, the previously specified study value of α is 0.05, evaluation of the kinesthetic outcome did not identify a more extreme set of kinesthetic learner preferences for study participants at-risk and not at-risk.

Table 5. Contingency table and Fisher exact test results for kinesthetic preference

Kinesthetic outcome: *P* = 0.554			
	Not kinesthetic	Kinesthetic	Row sums
At-risk	15	20	35
Not at-risk	49	48	97
Column sums	64	68	132

Conclusions

The primary reasoning for the continual need of targeted at-risk student research is to further form and supplement student retention initiatives through an expanded data-derived knowledgebase. Year-to-year enrollment patterns, programmatic completion, graduation rates, as well as academic attainment information concerning at-risk students demonstrates progress, but longitudinal educational, social, and professional information will serve as the true cross-sector indicator of successful efforts (Swail, 2009). Among these efforts are CTE initiatives that have and continue to implement innovative approaches and methods that at-risk learner considerations are a foci (Ernst & Clark, 2010; Clark & Ernst 2010; Clark & Ernst, 2009a; Clark & Ernst, 2009b; Ernst, October, 2009).

CTE implements a concerted educational approach to provide enhanced understandings by engaging learners through visual and kinesthetic reinforcement (Ernst & Clark, 2010). CTE Engineering/Technical Graphics high school students participating in this study had an identifiable preference toward kinesthetic learning. However, visual learning preference places last proportionally to aural learning and reading-based learning. VARK frequency results presents information that CTE reinforcement activity, specifically Engineering/Technical Graphics, could lend itself to becoming more differentiated in efforts to target specific student groups of learners instead of a visual and kinesthetic systematically-based approach. Huebner (2010) identifies that there are a number of validated practices that provide the foundation of differentiation beyond responding to student learning styles, including successful classroom organization procedures, supporting student commitment and motivation, evaluating student readiness, and assembling students strategically. However, learner preferences and styles of student learning remain foundational to varied and multimodal learning approaches that culminate in effective differentiated instruction.

Learner preference, differentiated practice, and curricular implementation frameworks are only a few factors in understanding and structuring educational environments for at-risk learners. Vlachou, Didaskalou and Argyrakouli (2006) conclude in a learner preference study concerning students with documented categorical educational difficulties that students do not collectively favor one delivery mode over other delivery alternatives. However, educational successes for students are largely determined by learning compatibility, as well as experiences (Felder & Silverman, 1988).

Addressing educational needs through instruction, practice, and implementation is not enough, as research indicates that at-risk students excel when they have a sense of belonging, effective courses are offered and an asset-based approach is employed (Calabrese, Hummel, & Martin, 2007). Statistically, this study detects that there are no identifiable learner preference differences between study participants categorized as at-risk and not at-risk. This study could have further benefitted from a categorical identifier mechanism that would have determined the individual criteria resulting in each at-risk student classification. This information could have provided specific insight into subset at-risk student groups of CTE and targeted classification learner preference. However, overall CTE Engineering/Technical Graphics student learning preference and comparison preference for at-risk Engineering/Technical Graphics students was achieved.

Although very exploratory in nature, this study directly investigates and identifies that the general population of CTE learners shares common learner preference and demonstrates the possibility that instruction, practice, and implementation can be uniformly addressed in CTE Engineering/Technical Graphics and maintain preferential methods of learning for at-risk and not at-risk students alike.

Engineering graphics educators at the secondary level, as well as the post-secondary level, encounter unique learner subsets and leaner dynamics. In many ways, the content of engineering graphics itself caters to broad learner groups whether they prefer visual, aural, reading, kinesthetic, or multimodal modes. However, specific awareness of learner subsets and attention to reflection on educational approaches and instructional design strategies must be maintained, in addition to identification of preferential methods, to maximize student receptiveness and engagement in engineering design graphics.

References

Ausburn, L.J. & Brown, D. (2006). Learning strategy patterns and instructional preferences of Career and Technical Education students. *Journal of Industrial Teacher Education*, 43(4), 6-39.

Calabrese, R.L., Hummel, C., & Martin, T.S. (2007). Learning to appreciate at-risk students. *International Journal of Educational Management*, 21(4), 275-291.

Clark, A.C & Ernst, J.V. (2009a). STEM-based computational modeling in technology education. *Journal of Technological Studies, 34*(1), 20-27.

Clark, A.C & Ernst, J.V. (2009b). Gaming research for technology education. *Journal of STEM Education, 10*(2), 25-30.

Clark, A.C. & Ernst, J.V. (2010). Computational modeling: Projects and innovations for technology education. Refereed proceedings of the International Association for Technology, Education, and Development's International Technology Education and Development Conference, Valencia, Spain, ISBN: 978-84-613-5538-9, 2056-2067.

Day, S.L. (2002). Real kids, real risks: Effective instruction of students at risk of failure. *National Association of Secondary School Principals*, 86(632), 19-32.

Ernst, J.V. (October, 2009). Engineering or not? Invited paper presented at the 96th Mississippi Valley Technology Teacher Education Conference, Nashville, TN.

Ernst, J.V. & Clark, A.C. (2010). Virtual and physical modeling: A curricular design for at-risk students in career and technical education. Refereed proceedings of the International Association for Technology, Education, and Development's International Technology Education and Development Conference, Valencia, Spain, ISBN: 978-84-613-5538-9, 1992-2000.

Felder, R.M. & Silverman, L.K. (1988). Learning and teaching styles in engineering education. *Journal of Engineering Education*, 78(7), 674-681.

ISSN: 1949-9167

Fleming, N., & Baume, D. (2006) Learning styles again: VARKing up the right tree!, *Educational Developments*, 7(4), 4-7.

Fleming, N.D. (1995). I'm different; not dumb. Modes of presentation (VARK) in the tertiary classroom, in Zelmer,A., (ed.) Research and Development in Higher Education, *Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia (HERDSA)*,HERDSA, Volume 18, pp. 308 – 313.

Gellevij, M., Van Der Meij, H., Jong, T.D., & Pieters, J. (2002). Multimodal versus unimodal instruction in a complex learning context. *The Journal of Experimental Education*, 70(3), 215-239.

Goorha, P. & Mohan, V. (2010). Understanding learning preferences in the business school curriculum. *Journal of Education for Business*. *85*, 145-152.

Hancock, V.E. (1992). The at-risk student. *Educational Leadership*. *50*(4), 84-85.

Hatch, B. (2009). Challenge *handbook: Information for special populations coordinators and administrators in North Carolina*. Raleigh, NC: North Carolina Department of Public Instruction.

Huebner, T.A. (2010). Differentiated instruction. *Educational Leadership*. *67*(5), 79-81.

Kennedy, R.L., & Morton, J.H. (1999). A *school for healing: Alternative strategies for teaching at-risk students*. New York, NY: Peter Lanh Publishing, Inc.

Kirkman, T.W. (1996) *Statistics to use*. Retrieved from http://www.physics.csbsju.edu/stats/

Leite, W.L., Svinicki, M. & Shi, Y. (2010). Attempted validation of the scores of the VARK: Learning styles inventory with multitrait-multimethod confirmatory factor analysis models. *Educational and Psychological Measurement*, *70*(2), 323-339.

North Carolina Department of Public Instruction. (2005). *Trade Industrial Education: 7972 Drafting II-Engineering Curriculum.* Retrieved from http://www.ncpublicschools.org/docs/cte/trade/curriculum/programs/guide/drafting2-engineering.pdf

Reid, J.M. (1987). The learning style preferences of ESL students. *Teachers of English to Speakers of Other Languages*. *21*(1), 87-111.

Sagor, R., & Cox, J. (2004). At-*risk students: Reaching and teaching them* (2nd ed.). Larchmont, NY: Eye on Education, Inc.

Sheskin, D.J. (2007). Handbook *of parametric and nonparametric statistical procedures* (4th ed.). New York, NY: Chapman and Hall.

Spratt, M. (1999). How good are we at knowing what learners like? *System*, 27, 141-155.

Swail, W.S. (2009). *Graduating at-risk students: A cross-sector analysis*. Washington, DC: Imaging America Foundation.

Vlachou, A., Didaskalou, E., & Argyrakouli, E. (2006). Preferences of students with general learning difficulties for different service delivery modes. *European Journal of Special Needs Education*, 21(2), 201-216.

Windsor, J., Piche, L.M., & Locke, P.A. (1994). Preference testing: A comparison of two presentation methods. *Research in Developmental Disabilities*, 15(6), 439-455.

About the Author

Jeremy V. Ernst is an assistant professor in the Integrative STEM Education Program at Virginia Tech in Blacksburg. His research interest is in the area of students at-risk in STEM education. Prior to joining the Virginia Tech faculty, he was an assistant professor in the Department of Science, Technology, Engineering, and Mathematics Education at North Carolina State University, Raleigh, where he earned his Ed.D.
Email: jvernst@vt.edu