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

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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

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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

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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

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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

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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

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ISSN: 1949-9167

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

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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,

ISSN: 1949-9167

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.

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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.

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