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Preferential Learning of Students in a Post-Secondary Introductory Engineering Graphics Course: A Preliminary Study Focused on Students At-Risk

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Abstract

This study follows a thematic trend in research that gauges engineering graphics student preferences, abilities, and consequent approaches and curricular designs for instructors. Students' backgrounds, attitudes, beliefs, and behaviors are considered to directly affect learning in the classroom; therefore, research is needed as to how students learn in the content that we teach. This study used the VARK Questionnaire to identify the preferred learning approaches of students in an introductory engineering graphics class at a major university. The questionnaire indicates whether a person prefers one or multi-modal learning methods that include (V)visual, (A)aural, (R)read/write, and (K)kinesthetic. A demographic instrument was employed to gather data that assisted in classifying students as being at-risk of leaving college or not at-risk. The researchers used the Fisher exact test to analyze the collected data. 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.[1] 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 (p.633).[1] Students who took the VARK Questionnaire (n=132) had an overall high preference of kinesthetic learning at 27.4% indicating this is how they prefer to learn, with visual (16.9%) being the least preferred learner preference. Forty-two of the participants were classified as at-risk and no significant difference was identified within each learner preference between at-risk and not at-risk groups. The findings from this preliminary study support previous research conducted in engineering design graphics courses at the high school level.[2] A major recommendation is to fully incorporate differentiated instructional methods and applications to promote learning in engineering graphics at the post-secondary level, not solely virtual modeling when teaching students how to visualize technical information.

Introduction

A trend over the past decade within all levels of education has been to associate learning styles to the way instruction should be administered to students for best learner outcomes in any given subject, and engineering graphics is no exception. Most of these studies have used standardized instruments that will indicate a learning style and the best method to convey information to students with a particular learning style or how to address multi-modal learners. Most of these studies have focused on visual and reading learning capabilities of students through studies in cognitive science or educational psychology. The researchers for this study considered the historical trend in this area but with different issues to address. First, research has indicated that students have a preferred learning style that they use, not so much as to one that standardized instruments indicate that they have as their strongest learning modal. Second, the role of a student's preferred learning style and the possibility of addressing learning issues for students that are deemed as-risk at the post-secondary level warrants specific exploration. Considering these points of interest from the researchers, this study used the VARK Questionnaire to identify the preferred learning approaches of students in an introductory engineering graphics class at a major university and identified students that would be considered at-risk of not completing their studies in degree programs within engineering. The questionnaire indicates whether a person prefers one or multi-modal learning methods that include (V)visual, (A)aural, (R)read/write, and (K)kinesthetic. It was assumed by the researchers that students in an introductory engineering graphics course at the sophomore level with an overall GPA of 3.0 or less could be classified as at-risk of not graduating with an engineering related degree. Therefore, those students taking this course also have a strong tendency to be visual learners as a preferred learning style. Considering these assumptions, the researchers wanted to focus on learning preferences of students in an introductory engineering design graphics course and particularly those deemed at-risk.

Research Questions

This study consisted of two overarching research questions related to learner preferences in a post-secondary classroom. The primary research question was: What are the learning preferences for college students taking a fundamental engineering design graphics courses? As a follow-up question to the primary question the investigators explored: Do students taking a college engineering design course and categorized as "at-risk" have different learning preferences than students categorized as "not at-risk?" The primary research question was investigated and analyzed through frequency-based ordinal data pertaining to student learner preference(s). The second research question was evaluated through data analyzed in contingency tables, the Fisher exact test computation for these contingency tables, and their relative small sample sizes.

Method

The frequency table displays a summarized grouping of all participants based on their learning preferences. The five contingency tables for visual, aural, reading/writing, kinesthetic and multi-modal learning preferences provide the numbers of each categorical learner (at-risk or not at-risk) 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.[2] The chi-square distribution provides an approximation of the exact sampling distribution for a contingency table.[1] Sheskin also identifies that while the sample size is small, the Fisher's exact test is recommended. Five hypotheses of statistical differences between the two sample subgroups were assessed with the Fisher exact test. 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 from the data obtained (p.633).[1] This study was conducted in both summer and fall semesters of 2012 at a large state university in the Southeast of the United States.

Instrument Overview

VARK is a questionnaire that provides users with a profile of their learning preferences. These preferences focus on the ways in which people like information to come to them and the ways in which they like to deliver their communication. The VARK measures four perceptual preferences: visual (V), aural (A), read/write (R), and kinesthetic (K).
The VARK preference for intake and output information is only one but important dimension of a learning style which has more than 18 dimensions (such as preferences for temperature, light, food intake, biorhythms, working with others, working alone).[4] Fleming, the developer of VARK instrument, attempted to establish perceptual modes as measurable and was influenced by research in neurolinguistic programming, suggesting that individuals receive information through sensory modalities and have sensory modality preferences.[4] The strength of VARK instrument lies in its educational value for helping people think about their learning in multiple ways and giving them options they might not have considered.[5]

The current VARK questionnaire contains 16 multiple choice questions based on situations where there are choices and decisions about how that communication might take place. Each question offers four answers with each answer corresponding to one of the four preferences. Participants are allowed to choose more than one answer. The answers are accumulated by mode and the highest score determines whether the participant is Visual, Aural, Read/Write, or Kinesthetic.[6] If the participant has no clear preference for any one mode – or has equally strong preferences for two, three or four modes, a multimodal (MM) is determined. Over 180,000 people have used VARK online from mid-March to mid-September 2006.[5] As reported on the VARK website, the online version for September 2011 had over 200,000 respondents and many more used the questionnaire in paper format elsewhere.[3]

Validity and Reliability

According to the nature of VARK that it is not a semantic quiz and designed as an advisory tool for student and faculty development, VARK's content validity is strong and does not have predictive validity.[6] Despite its popularity, there is very little rigorous attempt to establish the validity of the scores of the VARK questionnaire. In the research by Leite, Svinicki and Shi (2010), the dimensionality of the VARK learning styles inventory was valued through comparison of four multitrait-multimethod confirmatory factor analysis models, and the result showed that the correlated trait-correlated method model had the best fit to the VARK scores.[4] The study found preliminary support for the validity of the VARK scores. Further, estimates of reliability were provided based on confirmatory factor analysis.[4] The reliability estimates for the scores of the VARK subscales were .85, .82, .84, and .77 for the visual, aural, read/write, and kinesthetic subscales, respectively, which are considered adequate given that the VARK is not used for high-stakes decisions. As Fleming cited, VARK instrument was not designed to be reliable in terms of consistency of scores over a long period of time, but provide students with effective learning strategies to use based on their learning preference(s).[6]

VARK Modes

Fleming[6] designed the VARK to measure four different perceptual preferences for the input of information, which are visual (V), aural (A), read/write (R), and kinesthetic (K) defined as follows:

Visual (V): This mode includes the information in charts, graphs, flow charts, and all the symbolic arrows, circles, hierarchies and other devices that teachers use to represent what could have been presented in words. This mode does not include these media: pictures, movies, video and animated websites because they use a combination of many modes (multimodal) mainly kinesthetic, read/write and aural.

Aural (A): This perceptual mode describes a preference for information that is "heard and spoken." Students with this modality report that they learn best from lectures, group discussions, tutorials, student seminars and talking with other students.

Read/Write(R): This modal preference is for information displayed as text and printed words. Many teachers have a strong preference for this modality.

Kinesthetic (K): This modality refers to the "perceptual preference related to the use of experience and practice (simulated or real)." Although such an experience may include other modalities, the key is that the student is connected to reality, "either through experience, example practice or simulation."[6] This is where students use many senses (sight, touch, taste, hearing, speaking and smell) to experience something new.

Multimodal (MM): Multimodal refers to who has no clear preference for any one of the former four modes or who has equally strong preferences for two, three or four modes. Multimodals have choice and flexibility. They use the mode that suites them best or that suites the teacher or the subject or the day or their mood.

Analysis

The frequency tabulation was conducted in order to provide an indication of learning preferences for all participants. The contingency tables for visual, aural, reading/writing, kinesthetic and multi-modal 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.[2] The chi-square distribution provides an approximation of the exact sampling distribution for a contingency table.[1] While the sample size is small, the Fisher exact test is recommended.[1] Besides, the p-values obtained through the Fisher exact test provide exact p-values.[7] Based on previous statements, five hypotheses of statistical differences between the two sample subgroups were assessed with the Fisher's exact test. 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 from the obtained data (p.633).[1]

Data and Findings

Table 1 show the overall frequency of students who took the VARK in the fundamentals of engineering design graphics courses during summer and fall semesters of 2012. Participants can potentially be categorized within multiple preferences and also identified as multimodal. In the case of Table 1, there are 402 overall preference counts based on the 132 respondents.

Table 1 Frequency table for students

Preference	Frequency	Relative Frequency
V	68	0.169
A	74	0.184
R	70	0.174
K	110	0.274
Multimodal	80	0.199
Column sums	402	1.000

Table 2 shows the contingency table and outcomes from the Fisher exact test for the Visual learner preference from the VARK instrument.

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

Visual outcome: P=0.709	Not visual	Visual	Row sums
At-risk	19	23	42
Not at-risk	45	45	90
Column sums	64	68	132

Table 3 shows the contingency table and outcomes from the Fisher exact test for the Aural learner preference from the VARK instrument.

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

Aural outcome: P=0.707	Not aural	Aural	Row sums
At-risk	17	25	42
Not at-risk	41	49	90
Column sums	58	74	132

Table 4 shows the contingency table and outcomes from the Fisher exact test for the Reading learner preference from the VARK instrument.

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

Reading outcome: P=0.577	Not reading	Reading	Row sums
At-risk	18	24	42
Not at-risk	44	46	90
Column sums	62	70	132

Table 5 shows the contingency table and outcomes from the Fisher exact test for the Kinesthetic learner preference from the VARK instrument.

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

Kinesthetic outcome: P=0.623	Not kinesthetic	Kinesthetic	Row sums
At-risk	15	20	35
Not at-risk	49	48	97
Column sums	64	68	132

Table 6 shows the contingency table and outcomes from the Fisher exact test for the Multimodal learner preference from the VARK instrument.

Table 6 Contingency table and Fisher exact test results for multimodal preference

Multimodal outcome: P=0.347	Not multimodal	Multimodal	Row sums
At-risk	14	28	42
Not at-risk	38	52	90
Column sums	52	80	132

Conclusions

Based on this study, conclusions and recommendations can be formulated pertaining to pedagogy specific to engineering design graphics. First, kinesthetic learner preference from the VARK instrument is the overall preferred preference for learning and can be directly related to the overall learning of materials in this type of laboratory and lecture based engineering graphics course. Multimodal is next, or second in preference as a preferred method of learning from students in this introductory engineering graphics class. This is suggestive that a need exists for instructors to use a variety of learning approaches for engineering graphics courses, not exclusively focused on visual modes. Although our outcomes related to the courses we teach are mainly centered on visual literacy and/or visual science, the findings of this study uncover a need to consider individual student uniqueness. This is accomplished through incorporating the use of various methods of instruction, including technologies. Finally, this study indicates, as does previous research conducted thematically by the authors of this paper, that there is no difference in learner preference for students categorized “at-risk”, versus “not at-risk” learners.[2] It has been previously established, therefore, the findings from this study are confirmatory between secondary and post-secondary education. These most recent findings maintain consistent results across the breadth of academic learner levels when engaged in engineering design graphics and application. Considering this, we can address instructional needs for “at-risk” and “not at-risk” students with consistent form. More research like this is needed to better understand our students and develop improved methods of instruction in engineering design classrooms.

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