Students' Preferred Learning Styles in Graphic Communications

Jeremy V. Ernst and Aaron C. Clark
North Carolina State University

Abstract

The objective of this study was to identify changes in dominant preferred learning styles of students based on instructional presentation of course content. This study evaluates dominant preferred learning styles of two groups of university students. The first group of students was enrolled in a course that introduces graphical representation in an introductory engineering design graphics course. In this course, information was primarily conveyed to students through visual-based instruction. The second group of students was enrolled in a technology-based course focusing on materials processing. In this second course, content was reiterated to students through laboratory discovery experiences in materials testing and construction of multi-material projects. Students' dominant preferred learning styles are evaluated with the VARK Questionnaire and categorized as (V) visual, (A) aural, (R) reading, or (K) kinesthetic. The VARK Questionnaire was distributed to both student groups before the onset of instruction. The VARK Questionnaire was distributed once more to student groups at the midterm of each course. Changes in dominant preferred learning styles of students were evaluated. Cross group comparisons are made to identify variations in dominant preferred learning styles provided the two instructional approaches. A major finding for students in the engineering design graphics course is that their change in learning preference is not influenced by instructional presentation.

INTRODUCTION

Technology and engineering has played major roles in fostering the US economy. Many companies consider engineering the 'driving-force' behind their success and their growth. They also feel it will help them remain competitive in the global market place in the coming years (Clark and Scales, 2006). However, varying degrees of economic recession have recently been noted worldwide resulting in industrial, technology, and engineering associated practitioners searching for ways to contribute to the competitive edge of the education of future professionals (Azevedo and Akdere, 2006). Previous research has uncovered that learning preferences and cognitive abilities of individuals may play a significant role in overall preparation or training outcomes (Jarvis and Woodrow, 2005; Lee, 2001; Daghita, Dudley, Heekin, and Terry, 2002). This is of particular interest to those in areas of engineering/technical graphics education due to the constant need to improve the communication capabilities of engineers and technologist (Sadowski, Birchman, and Harris, 2005). By having students use and understand visual science as a foundation, they will help make companies more efficient and cost effective in the future (Hartman, 2003). Therefore, learning preferences and patterns of students and their relationships with instructional practices have been topics of wide debate for approximately 40 years for improving student learning. Prior to this time, the bulk of student learning research had a primary focus on cognitive processing strategies and motivation (Vermunt and Vermetten, 2004). While associations between student successes, cognitive and motivational strategies have been made (Curran and Smith, 2005; Fuhler, Farris, and Nelson, 2006; Komarchuk, Swenson, and Warkocki, 2000; Soares, Lemos, and Almeida, 2005), researchers remain to argue the relationships between student learning preference and instructional approach. The learning style and instructional approach theme has continuing regard despite the lack of supporting evidence and research in the areas (Stahl, 1999). In the discipline of engineering/technical graphics, many researchers have studied the use of learning styles of students in both lecture and laboratory situations, but few have attempted to link their research to instructor bias in the classroom and the use of preferred learning styles of students as a measure of learning gains and improvements.

Much as students have preferred ways of learning, graphics faculty have preferred ways of teaching. Most professors will teach the way they were taught and how they learn best even at the detriment of student learning (Sadowski, Birchman, and Harris, 2005). Student learning styles often form the encounters that students have with faculty. Learning styles are shaped by experiences; consequently, instructional approaches can further shape the learning styles of students (Grasha, 2002). Course designs in graphic communications are generally structured to appeal to varied senses for the acquisition of information even though many are presented in a visual-based instructional manner. However, it is inherent that certain content will call for a focused instructional approach that does not proportionally appeal to sensory channels. Fleming and Mills (1992), conclude through longitudinal observations that the "most realistic approach to the accommodation of learning styles in teaching programs should involve empowering students through knowledge of their own learning styles to adjust their learning behavior to the learning programs they encounter." Presented with the statements and findings from Grasha (2002), Fleming and Mills (1992), and lack of research and supporting evidence cited by Stahl (1999), further research is needed to identify changes in learning styles of students based on instructional presentation of course content. To address this identified need, a study was conducted on effects of instructional presentation on dominant preferred learning styles in university students that includes students in a fundamentals of engineering design graphics course.

INSTRUMENTATION: THE VARK QUESTIONNAIRE

The VARK Questionnaire is used in this study to assess learning preferences of university students. The questionnaire is employed to determine if the students' dominant preferred learning styles are visual, aural, read/write, or kinesthetic. In 1987, Neil Fleming of Lincoln University, New Zealand developed the VARK Questionnaire. It diverges from the majority of learning styles instruments in that its principal intent is to be consultative rather than pointing and prognostic. The major additive component that separates the VARK Questionnaire from other preferred learning style advisories is the fourth category, read-write. This addition to the visual, aural, and kinesthetic characteristics defines perceptual learning styles by subdividing the visual mode into symbols and text (Miller, 2001). 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. The most familiar method for information transfer in our society is speech. 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 read/writers (R) since they use reading and writing 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, multi-sensory experiences in their learning.

The VARK Questionnaire is composed of 16 questions that assist in identifying preferred learning styles. Participants are directed to choose the answer that best explains their preference and circle the letter(s) next to it (Fleming, 2006). If any single answer does not match their perception, then the participant is asked to circle more than one answer. Also, participants were permitted to leave blank any question that does not apply. Once participants have completed the VARK Questionnaire, they were to use the marking guide found on the last page of the questionnaire. The scoring chart was completed by circling the letter V, A, R, or K in the column that corresponds to the answer selection on the questionnaire. Once the scoring chart was completed, participants calculate their scores by counting and totaling the number of Vs, As, Rs, and Ks.

METHODOLOGY

In the spring semester of 2007, two groups of students were selected to participate in a preferred learning style research study. The study provided both visual and hands-on treatments in a sample of convenience. The first group of students was enrolled in a course that introduces graphical representation. This course is the first in the series of technical graphics courses for graphic communications majors and minors, as well as a general education course for the university. Course competencies are based on the learning of visual science and understanding with the generation of graphic-based solutions for 2D and 3D spatial problems. Information is primarily conveyed to students through a visual-based instruction approach where the instructor provides an overview of the fundamentals and applications of computer graphics and computer-aided design. All pedagogy and learning outcomes are based on the creation and demonstration of virtual models. Therefore, the researchers identified this course to represent the visual treatment group. The second group of students was enrolled in a course focusing on materials processing like those taught in introductory engineering technology courses that are very much laboratory-based for students to learn materials and processes. This introductory course introduces the students to basic content and skills needed to process common materials and produce functional products using woods, metals, plastics, and composite materials. This course also includes laboratory safety, use of hand tools, and operation of machinery. Course content is reiterated to students through laboratory discovery experiences in materials testing and construction of multi-material projects. Pedagogy and learning outcomes are based on the creation and demonstration of physical products. Therefore, the researchers identified this course to represent the hands-on treatment group.

Given the principal research question, Does instructional presentation style have a measurable effect on the dominant preferred learning styles of university students?, eight null hypotheses were postulated and evaluated:

1. There is no change in student visual learning preference when exposed to visual-based instruction.
2. There is no change in student visual learning preference when exposed to hands-on instruction.
3. There is no change in student aural learning preference when exposed to visual-based instruction.
4. There is no change in student aural learning preference when exposed to hands-on instruction.
5. There is no change in student reading learning preference when exposed to visual-based instruction.
6. There is no change in student reading learning preference when exposed to hands-on instruction.

7. There is no change in student kinesthetic learning preference when exposed to visual-based instruction.
8. There is no change in student kinesthetic learning preference when exposed to hands-on instruction.

These eight hypotheses were generated as the basis for investigation provided previous analysis and discussion on instructional practice and preferential learning in educational settings utilizing differentiated types of instruction (Emerson and Taylor, 2007; Wang, Wang, and Wang, 2006). Rakow (2007) describes how schools, curricula, and instruction can be structured to meet the needs of students in a variety of settings. One of her evaluative suggestions is to conduct a pre-assessment through a learning styles inventory, identify instructional trends, complete tiered assignments and learning activities, and administer an instrument that will enable the identification of changes including preferential learning.

Additionally, two correlation matrixes were developed from calculated change in VARK pretest and posttest ratings to show how strongly each preferred learning style is related, given the visual-based instruction method for group one and the hands-on materials testing and construction method of instruction for group two.

The VARK Questionnaire and the demographics survey were distributed to the instructors of the visual-based instruction course (i.e. fundamentals of graphics course) and the hands-on materials testing and construction course (i.e. technology materials and processes introductory course). The purpose of waiting until midterm to administer the second round of the VARK questionnaire was to allow ample exposure to the instructional approaches. Both instructors administered the VARK Questionnaire and demographics survey to their students, where they were informed that they were not required to take the questionnaire and survey. The willing student participants completed the VARK Questionnaire and the demographics survey, which takes approximately 5-7 minutes. The VARK Questionnaire and demographics survey were collected by the instructor and returned to the researchers.

The VARK Questionnaire and the second round demographics survey was distributed once more to both student groups at the midterm of each course. The second round demographics survey was an abbreviated form or the original demographics survey. The purpose of altering the instrument was to reduce the acquisition and entry of duplicate information. Both instructors administered the VARK Questionnaire and the second round demographics survey to their students, where they were once again informed that they were not required to take the questionnaire and survey. The willing student participants completed the VARK Questionnaire and demographics survey, and they were again collected by the instructor and returned to the researchers. Both rounds of preferred learning style data and demographics information for the two groups were entered and analyzed for differences and associations.

DEMOGRAPHICAL INFORMATION

The two groups in this study were composed of 53 university student participants. The two groups represent a variety of majors ranging from engineering to education. The majority of students in the hands-on materials testing and construction group were education and engineering majors. As for the visual-based instruction group, students represented a variety of majors due to this "fundamentals of graphics course" being a general education course for the university as a whole. The 53 participants were predominately male. The study had only three female participants, two in the visual-based instruction group and one in the hands-on materials testing and construction group. The majority of the student in the visual-based instruction group were ages 18-20 (90%) and report their academic levels as either freshman or sophomore (95%). Refer to Table 1 for further gender, age, and academic level breakdown of the visual-based instruction group.

Table 1: *Gender, Age, and Academic Level for Visual-Based Instruction Group*

Gender		Age		Academic Level	
Male	95%	18 or less	54%	Freshman	65%
Female	5%	19-20	36%	Sophomore	30%
		21-22	5%	Junior	5%
		23-24	5%	Senior	0%
		25 or more	0%	Graduate	0%

The hands-on materials testing and construction group represent a broader variety of student ages and academic levels. Collectively, participants in group two appear to be slightly older than the visual-based instruction group and have higher academic classification levels. Refer to Table 2 for further gender, age and academic level breakdown of the hands-on materials testing and construction group.

Table 2: *Gender, Age, and Academic Level for Hands-On Materials Testing and Construction Group*

Gender		Age		Academic Level	
Male	94%	18 or less	19%	Freshman	25%
Female	6%	19-20	44%	Sophomore	19%
		21-22	37%	Junior	19%
		23-24	0%	Senior	37%
		25 or more	0%	Graduate	0%

DATA ANALYSIS

Comparative analyses were conducted for student participant responses for the visual-based instruction group (i.e. fundamentals of graphics course) as well as for the hands-on material testing and construction group (i.e. technology materials and processes introductory course). Summary statistics were generated to summarize the sets of responses. Mean, variance, standard deviation, and standard error were calculated for the visual-based and hands-on group for change in visual preferred learning styles (Table 3), change in aural preferred learning styles (Table 4), change in reading preferred learning styles (Table 5), and change in kinesthetic preferred learning styles (Table 6).

Table 3: *Summary Statistics for Change in **Visual** Preferred Learning Style*

Group	n	Mean	Variance	Std. Dev.	Std. Err.
Visual-based	37	0.40541	9.41441	3.06829	0.50442
Hands-on	16	-0.375	11.05	3.32415	0.83104

Table 4: *Summary Statistics for Change in **Aural** Preferred Learning Style*

Group	n	Mean	Variance	Std. Dev.	Std. Err.
Visual-based	37	-.03784	5.13063	2.26509	0.37238
Hands-on	16	-1.5625	11.4625	3.38563	0.84641

Table 5: *Summary Statistics for Change in **Reading** Preferred Learning Style*

Group	n	Mean	Variance	Std. Dev.	Std. Err.
Visual-based	37	-0.5405	5.1997	2.28029	0.37488
Hands-on	16	0.8125	8.1625	2.85701	0.71425

*Table 6: Summary Statistics for Change in **Kinesthetic** Preferred Learning Style*

Group	n	Mean	Variance	Std. Dev.	Std. Err.
Visual-based	37	0.27027	7.92493	2.81512	0.4628
Hands-on	16	-0.4375	11.9958	3.4635	0.86588

The mean indicates an average of change in participant preferences on the VARK Questionnaire. The variance of the change in student participant preferences gives a sense of how closely the distribution of preferences is around the learning preference average. The visual-based instruction group variance range for the questionnaire varies from 5.13 (change in aural learning preference) to 9.41 (change in visual learning preference), while the hands-on material testing and construction group variance range for the questionnaire varies from 8.16 (change in reading learning preference) to 11.99 (change in kinesthetic learning preference). The smaller the calculated variance, the closer the individual preferences are to the mean. The standard deviation of the preferences provides information that indicates where the dispersion of preference falls given a standard average. The standard deviations of the visual-based instruction group's preferences range from 2.27 (change in aural learning preference) to 3.07 (change in visual learning preference). The standard deviations of the hands-on material testing and construction group's preferences range from 2.86 (change in reading learning preference) to 3.46 (change in kinesthetic learning preference). When a calculated standard deviation is around one, this will indicate a narrow collective dispersion of learning preference data. Based on this general rule, the analyses indicate relatively high rates of variability and a broad dispersion within preferences for all four learning styles for the visual-based instruction group and the hands-on material testing and construction group.

Several statistical procedures were used to further evaluate preferred learning styles of the two groups of students' pre instruction and post instruction. The principal research question for this study is: Does instructional presentation style have a measurable effect on the dominant preferred learning styles of university students? The VARK Questionnaire results indicate that before the onset of instruction the visual-based group have fairly evenly distributed preferred learning style ratings with a slight kinesthetic learning preference (Table 7). Similarly, the VARK questionnaire ratings after instruction has occurred present a slight kinesthetic learning preference (Table 8).

Table 7: *Preferred Learning Style* ***Pre*** *Treatment Ratings for Visual-Based Group*

Learning Style	Percentage
Visual	22%
Aural	24%
Reading	22%
Kinesthetic	32%

Table 8: *Preferred Learning Style* ***Post*** *Treatment Ratings for Visual-Based Group*

Learning Style	Percentage
Visual	24%
Aural	23%
Reading	20%
Kinesthetic	33%

Much as the visual-based instruction group, the VARK Questionnaire results indicate that before the beginning of instruction, the hands-on materials testing and construction group have fairly evenly distributed preferred learning style ratings with a slight kinesthetic learning preference (Table 9). Similarly, the VARK questionnaire ratings after instruction has occurred present a slight kinesthetic learning preference (Table 10).

Table 9: *Preferred Learning Style* ***Pre*** *Treatment Ratings for Hands-On Materials Testing and Construction Group*

Learning Style	Percentage
Visual	26%
Aural	24%
Reading	18%
Kinesthetic	32%

Table 10: *Preferred Learning Style* ***Post*** *Treatment Ratings for Hands-On Materials Testing and Construction Group*

Learning Style	Percentage
Visual	26%
Aural	19%
Reading	23%
Kinesthetic	32%

Hypothesis tests were conducted to provide greater insight of instructional presentation style and its effect on the dominant preferred learning styles of the university student participants using an alpha of .05. Eight null hypotheses were postulated:

1. There is no change in student visual learning preference when exposed to visual-based instruction.
2. There is no change in student visual learning preference when exposed to hands-on instruction.
3. There is no change in student aural learning preference when exposed to visual-based instruction.
4. There is no change in student aural learning preference when exposed to hands-on instruction.
5. There is no change in student reading learning preference when exposed to visual-based instruction.
6. There is no change in student reading learning preference when exposed to hands-on instruction.
7. There is no change in student kinesthetic learning preference when exposed to visual-based instruction.
8. There is no change in student kinesthetic learning preference when exposed to hands-on instruction.

In Table 11, hypotheses one and two are evaluated. Based on the corresponding proportional values to the calculations of the Wilcoxon nonparametric statistical procedure that uses a method for ranking changes in pre and post responses (Agresti and Finlay, 1997); hypothesis one: There is no change in student visual learning preference when exposed to visual-based instruction, and hypothesis two: There is no change in student visual learning preference when exposed to hands-on instruction, cannot be rejected. There is no indication of measurable difference, for the sample size used, between VARK visual ratings prior to visual-based or hands-on instruction and after visual-based or hand-on instruction.

Table 11: *Change in Pre and Post ratings for Visual Preferred Learning Style*

H0 : Change in visual = 0

HA : Change in visual ≠ 0

Group	n	n for test	Wilcoxon Stat.	P-value
Visual	37	28	238.5	0.4231
Hands-on	16	10	20.5	0.5037

In Table 12, hypotheses three and four are evaluated. Based on the calculations of the Wilcoxon Statistics and the corresponding proportional values, hypothesis three: There is no change in student aural learning preference when exposed to visual-based instruction and hypothesis four: There is no change in student aural learning preference when exposed to hands-on instruction, cannot be rejected. There is no indication of measurable difference, for the sample size used, between VARK aural ratings prior to visual-based or hands-on instruction and after visual-based or hands-on instruction.

Table 12: *Change in Pre and Post ratings for Aural Preferred Learning Style*

H0 : Change in aural = 0

HA : Change in aural ≠ 0

Group	n	n for test	Wilcoxon Stat.	P-value
Visual	37	31	194.5	0.2945
Hands-on	16	14	23.5	0.0718

In Table 13, hypotheses five and six are evaluated. Based on the calculations of the Wilcoxon Statistics and the corresponding proportional values, hypothesis five: There is no change in student reading learning preference when exposed to visual-based instruction and hypothesis six: There is no change in student reading learning preference when exposed to hands-on instruction, cannot be rejected. There is no indication of measurable difference, for the sample size used, between VARK reading ratings prior to visual-based or hands-on instruction and after visual-based or hands-on instruction.

Table 13: *Change in Pre and Post ratings for Reading Preferred Learning Style*

H0 : Change in reading = 0

HA : Change in reading ≠ 0

Group	n	n for test	Wilcoxon Stat.	P-value
Visual	37	31	173	0.1391
Hands-on	16	14	68	0.3393

In Table 14, hypotheses seven and eight are evaluated. Based on the calculations of the Wilcoxon Statistics and the corresponding proportional values, hypothesis seven: There is no change in student kinesthetic learning preference when exposed to visual-based instruction and hypothesis eight: There is no change in student kinesthetic learning preference when exposed to hands-on instruction, cannot be rejected. There is no indication of measurable difference, for the sample size used, between VARK kinesthetic ratings prior to visual-based or hands-on instruction and after visual-based or hand-on instruction.

Table 14: *Change in Pre and Post ratings for Kinesthetic Preferred Learning Style*

H0 : Change in kinesthetic = 0

HA : Change in kinesthetic ≠ 0

Group	n	n for test	Wilcoxon Stat.	P-value
Visual	37	27	215.5	0.5299
Hands-on	16	14	47	0.7519

Additionally, two correlation matrixes were developed from calculated change in VARK pretest and posttest ratings to show how strongly each preferred learning style is related, given the visual-based instruction method for group one and the hands-on materials testing and construction method of instruction for group two. Based on the correlation coefficients in the matrix (Table 15), there are no changes in preferred learning style ratings that indicate a strong relationship in group one. The strongest relationship is noted between aural and kinesthetic preferred learning styles (r = 0.356). Other preferred learning styles in the VARK rating of the visual-based instruction group, such as aural and reading (r = 0.271), visual and reading (r = 0.239), and visual and aural show minimal relationships.

Table 15: *Correlation matrix for VARK rating of the visual-based instruction group*

	V-Change	A-Change	R-Change
A-Change	0.203		
R-Change	0.239	0.271	
K-Change	0.064	0.356	0.075

Based on the correlation coefficients in the matrix (Table 16), there are numerous changes in preferred learning style ratings that indicate relationship in group two. The strongest relationships are noted between the aural and reading preferred learning styles (r = 0.788) and the visual and aural preferred learning styles (r = 0.525). There is evidence, based on calculated correlation coefficients of change in pretest and posttest ratings, that the learning preference of these preferred learning styles tend to increase or decrease together, although not in a directly proportional manner. The aural/visual and visual/aural learning preferences show heightened values before and after the hands-on materials testing and construction method of instruction treatment.

Table 16: *Correlation matrix for VARK rating of the Hands-On Materials Testing and Construction Group*

	V-Change	A-Change	R-change
A-Change	0.525		
R-Change	0.301	0.788	
K-Change	0.002	0.188	0.112

FINDINGS AND CONCLUSIONS

The analysis of data in this study indicates that instructional presentation does not have a significant effect on change in dominant preferred learning styles of university student participants, including those studying graphic communications. The lack of significance may not be a function of change in learning style, but in the validity of the learning style treatments themselves. However, there is evidence of correlations between changes in preferred learning styles for both the visual-based and hands-on groups. The strongest relationship is noted between aural and kinesthetic preferred learning styles in the visual-based group. Other preferred learning styles in the VARK rating of the visual-based instruction group, such as aural and reading, visual and reading, and visual and aural, show minimal relationships. The strongest relationships are noted between the aural and reading preferred learning styles and the visual and aural preferred learning styles in the hands-on group. There is evidence, based on calculated correlation coefficients of change in pretest and posttest ratings, that the learning preference of these preferred learning styles tend to increase or decrease together, although not in a directly proportional manner.

The strategies, techniques, and approaches that instructors in this study used to facilitate learning within the visual-based and hands-on groups appear to not be significantly influential when it comes to learning preference. This could potentially be from the age of the students. Younger students may be heavily influenced by instructional approach, as opposed to older students who have solidly formed their learning preferences. Given this possibility, additional research is needed to evaluate the influence that instructors have on his or her students, especially in lab-based courses (i.e. CAD, CAM, and CIM).

A learning assessment is recommended to compare actual learning style to preferred learning style within the same types of content, visual-based graphics and hands-on materials testing and construction. It is recommended that stratification be done to allow for more female participants. For future research at the post-secondary level, graduate students can be included to provide a greater variety of age ranges and educational experiences. Differences in student participants need to be controlled to provide for comparison of like samples. For example, the visual-based student participants come from a variety of colleges and majors, including graphic communications, while the hands-on student participants primarily come from just a few select colleges within the university.

The debate of preferred learning styles and instructional approaches is ongoing (She, 2005). In order to present students with the finest educational experience, we must carefully consider both content and context in curriculum development (Clark, Scales, and Petlick, 2005; Miller, 2000). Another central consideration is the diversity of learners and the implications for instructional design. Based on the findings of this research study as well as previous studies, further preferred and actual learning style research is recommended based on gender, age, background, educational level, and cultural influence. This is especially important research for those that teach graphic communications. Over the years, many in the profession have struggled to offer the best instructional practices to our students so that they may go on and become good visual communicators. The teaching of visual skill, identified by Siok and Fletcher (2001) as visual memory and visual analysis performance, is of importance for learners of all ages and levels. Professionals in graphics education need to appreciate that students coming into our classes have diverse learning styles and these styles can be enhanced as visual skill is developed. Although this is a "tall order", more research in this area for graphic communications will improve the instruction we give, the students understanding, and just as important, allowing a visual-based course to appeal to everyone enrolled so that all students can learn in a preferential way.

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