

COMPUTER AIDED DESIGN: LEARNING STYLE PREFERENCE EFFECT ON STUDENT LEARNING

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Abstract

In the Computer Aided Design (CAD) course at the United States Military Academy (West Point, NY), students learn two different design software packages, SolidWorks™ and MATLAB™. In the past, faculty members who are responsible for teaching the course have observed a difference in performance by the students in course homework assignments and examinations between the two software packages. In general, students performed higher on SolidWorks assignments. This poses the question: Does learning style preference affect the ability to learn different computer aided design tools?

One hundred and eleven students enrolled in either the Spring 2012 (n = 61) or Fall 2013 (n = 50) semesters of Computer-Aided Design were asked to participate in this Institutional Review Board exempted study. Each student was asked to take Felder's and Soloman's "Index of Learning Styles" questionnaire [1]. Of the four learning dimensions that are evaluated in the questionnaire, only the scores for two, Visual vs Verbal and Sequential vs Global, were examined in this study. These two dimensions seem to be most relevant to the research question. We expected that SolidWorks was more suited to learners who tend to be more visually and globally-oriented. Conversely, we expected MATLAB to be more suited for more verbally and sequentially-oriented students.

This paper discusses the results of our study. The raw data in the Visual/Verbal domain appear to support our hypothesis to suggest that verbal learners perform better in MATLAB programming than in SolidWorks modeling, whereas visual learners have a less distinct

difference in performance. A survey of students also indicates that a higher percentage of verbal learners prefer MATLAB compared to their visual counterparts.

Introduction

Theoretically, there are several different learning styles that can be observed in students. One way to assess these learning styles is to use the "Index of Learning Styles" designed by Richard Felder and Barbara Soloman [2]. The questionnaire assesses the students' learning styles based on four dimensions of learning: Active vs Reflective, Sensing vs Intuitive, Visual vs Verbal, and Sequential vs Global. This study focused only on the Visual vs Verbal and Sequential vs Global dimensions of the questionnaire. The purpose of this research is to determine the learning styles of the students enrolled in Computer Aided Design, as taught in the Mechanical Engineering Department at the United States Military Academy (West Point, NY) to determine whether different portions of the course are more targeted toward certain types of learners. The first portion of the course teaches a computer program that is typically used for mechanical design and simulation, while the second portion teaches a script-based computational program. We hypothesized that the first program was better suited for learners who tended to be more visually and globally-oriented. Conversely, we expected the second program to be better suited for learners who tended to be more verbally and sequentially-oriented. Further, an assessment of the correlation between the two learning dimensions was conducted to determine whether they independently describe distinct learning styles, or whether they are related. We expected that they would be independent measures.

Methods

One hundred and eleven students enrolled in either the Spring 2012 (n = 61) or Fall 2013 (n = 50) semesters of Computer-Aided Design were asked to participate in this Institutional Review Board exempted study. The students in this course learn two computer programs. The first program is SolidWorks (SolidWorks Corp; Waltham, MA). This program is a three-dimensional visual design program, where the students learn to use the available tools to design mechanical devices. They learn the importance of dimensioning, design for manufacture, material selection, and simulation modeling. This program requires the student to have a global sense of perspective and visual design. The second program they learn in the course is MATLAB (Mathworks; Natick, MA). This program is primarily a script-based program, where they learned to write sequential programs to carry out complex calculations.

In order to identify individual learning styles, each student was asked to take the "Index of Learning Styles" questionnaire. Of the four learning dimensions that are evaluated in the questionnaire, only the scores for Visual vs Verbal and Sequential vs Global were examined in this study. A score between -11 to 11 was calculated from the students' responses to the questions. For the Visual vs Verbal dimension, negative scores are indicative of a visual learner and positive scores are indicative of a verbal learner. For the Sequential vs Global dimension, negative scores are indicative of a sequential learner and positive scores are indicative of a global learner. The absolute value of the score is suggestive of the degree to which you fall into that category, where 11 is the strongest inclination for a given learning style. However the current study only categorized the students into *visual* or *verbal* and *sequential* or *global* learners and did not account for their actual score. In addition to the questionnaire, students were asked to indicate which program they preferred learning during the semester.

Both the learning dimension scores and program preference were then compared to a retrospective review of their performance on two mid-term examinations. The first examination focused on SolidWorks programming skills, while the second focused on MATLAB programming skills. There was no significant difference, overall, between the scores on the two exams (Exam 1 = 92.3% \pm 10.5; Exam 2 = 92.3% \pm 10.4, $p = 1.00$). The individual differences between the two exams were calculated and used as a dependent variable, where a positive change suggested that the individual performed better in the MATLAB exam, and a negative change was indicative of a better performance on the SolidWorks exam.

Analyses were performed separately for both the Visual/Verbal and Sequential/Global dimensions. For each dimension, a Mann-Whitney U test was conducted to compare the exam score difference between the two ranges (Visual vs Verbal, and Sequential vs Global). Additionally, for each dimension, the range into which each student fell based on their responses to the questionnaire was compared to their self-ascribed preference for one of the computer programs. The percent-distribution of each range of learners was compared between the two programs using an exact binomial test of goodness-of-fit. Finally, in order to determine whether the two learning dimensions were correlated to each other, Visual/Verbal learning scores were correlated to Sequential/Global learning scores by calculating the Kendall's Tau rank correlation coefficient.

Results and Discussion

An uneven distribution of students fell into each range of the two learning dimensions. Of the 111 students, in the Visual/Verbal dimension, 105 students were categorized in the visual range and 6 were categorized in the verbal range. In the Sequential/Global dimension, 79 students were categorized in the sequential range and 32 were categorized in the global range.

There were no significant statistical differences in the exam score differences between the two ranges for either learning dimension (Figures 1 and 2). There was an apparent disparity between visual and verbal learners, where visual learners did not tend to exhibit an examination score difference and verbal learners had an average 8% increase on the second exam. The raw data in the Visual/Verbal domain appear to support our hypothesis to suggest that verbal learners perform better in MATLAB programming than SolidWorks programming, whereas visual learners have a less distinct difference in performance. The raw data suggest that both the sequential and global learners performed better in MATLAB programming, although the difference was more pronounced in the global learners. It should be pointed out, however, that the extreme difference in distribution of students, particularly in the Visual/Verbal domain, may have limited the statistical findings.

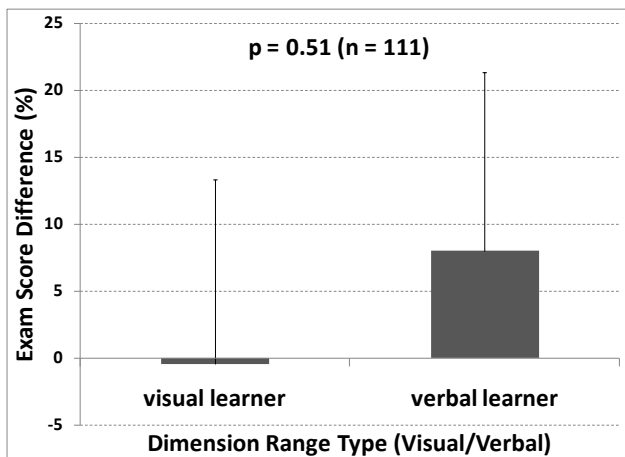


Figure 1: Visual vs Verbal Learners- Difference in Examination Scores.

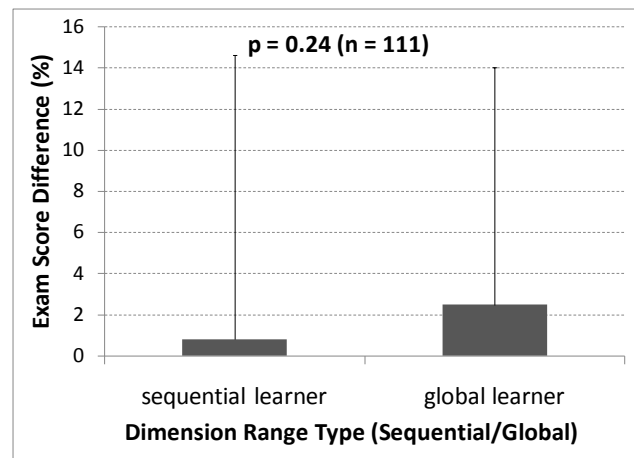


Figure 2: Sequential vs Global Learners- Difference in Examination Scores.

Data for program preference were only available for 51 students who opted to provide this data. For both learning dimensions, there was a significant difference in the distribution of preferred computer programs between the two ranges (Figures 3 and 4). In the Visual/Verbal dimension, both types of learners preferred SolidWorks to MATLAB, however there was a significantly higher percentage of visual learners who preferred the program over verbal learners, whereas the proportion of verbal learners that preferred MATLAB was comparably higher ($p = 0.01$). Similarly, in the Sequential/Global dimension, both types of learners preferred SolidWorks. However, a significantly higher percentage of global learners preferred the program over sequential learners, whereas the proportion of sequential learners who preferred MATLAB was comparably higher ($p < 0.01$). These results support our hypotheses in that, while SolidWorks was the overall favorite, MATLAB was preferred by significantly more verbal and sequential learners.

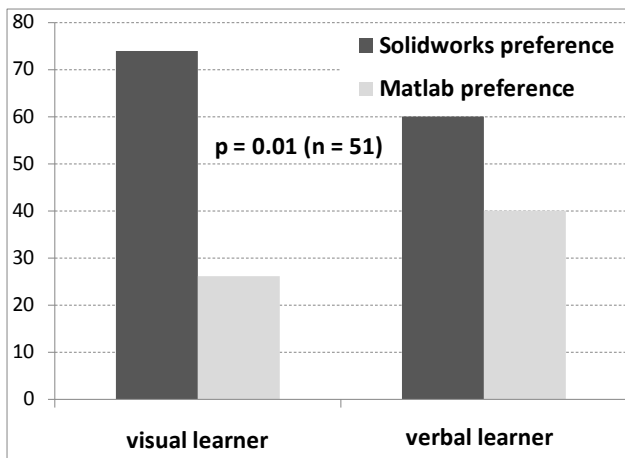


Figure 3: Visual vs Verbal Learners- Preference for SolidWorks or MATLAB Programming.

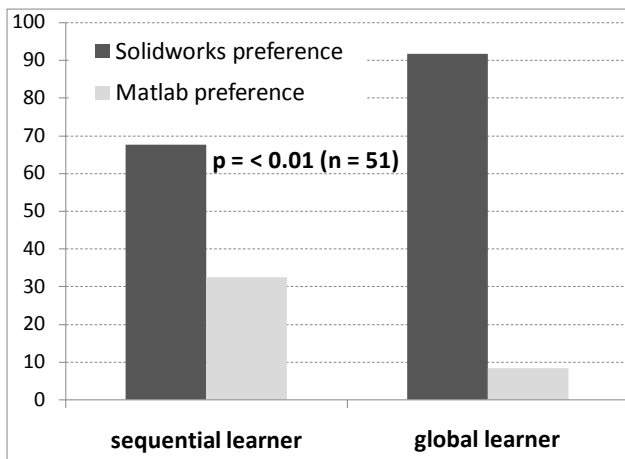


Figure 4: Sequential vs Global Learners-Preference for SolidWorks or MATLAB Programming.

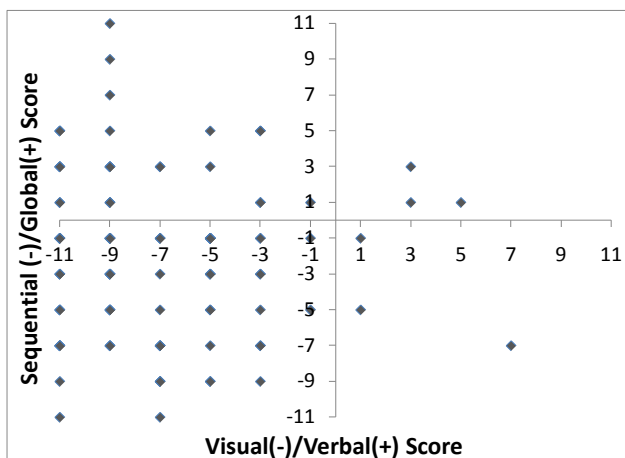


Figure 5: Correlation between Students' Scores in the Visual/Verbal and Sequential/Global Dimensions.

There was no significant relationship between the students' scores in the Visual/Verbal and Sequential/Global dimensions. As shown in Figure 5, there was no apparent correlation between the two scores. The graph also shows the proportionally larger number of sequential and visual learners in this experimental cohort.

Conclusions

In general, these findings support the concept that SolidWorks may be the easier program for learners who score more highly in the visual and global dimensions of the Learning Styles Inventory. It is difficult to assess whether MATLAB may be the easier program for learners who score more highly in the verbal and sequential dimensions since there were so few verbal and global learners. The large imbalance between the groups for these learning dimensions precludes some conclusions from this work. A future study might address this by conducting a similar study on a group of students that are not from a single major, as the participants in this experimental cohort were all engineering students in their second or third year of undergraduate study. A second factor that may have affected these findings is that SolidWorks was the preferred program by the majority of the students in this cohort. The reason for this is not clear, however it may be affected by the fact that SolidWorks was taught earlier in the semester. Furthermore, the method of teaching SolidWorks was significantly different than that of MATLAB. SolidWorks was mainly taught in a self-directed method through the use of computer tutorials, whereas MATLAB was more instructor-led with direct applications to engineering concepts. Future work should follow up with a cohort of students in their fourth year of undergraduate study to determine whether these preferences have persisted once they have had the opportunity to make use of both programs during their course of study.

The results of this study do support the concept of distinct learning dimensions. Although this study only assessed two of the

four learning dimensions that are evaluated by the Index of Learning Styles, those two dimensions appeared to be independent of each other. Furthermore, they seem to be good measures of student inclinations to excel in different types of computer programs. This supports the use of the Index of Learning Styles at the start of a course so that the instructor understands the students with whom they are engaging. It is also useful information, specifically for instructors of Computer Aided Design, in that they might expect a large majority of the students in their course to be visual, sequential learners and may gear their instruction appropriately. Additionally, they may need to work harder to instruct students in MATLAB programming, which may be less intuitive to the students, but is an important tool for engineering concepts.

Bibliography

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Biographical Information

Dr. Rebecca Zifchock joined the faculty at the United States Military Academy in 2010 after receiving her Bachelors degree in Biological and Mechanical Engineering at Cornell University, and Masters and Ph.D. degrees in Biomechanics at the Pennsylvania State University and the University of Delaware, respectively. She has over 12 years of research experience in the field of lower-extremity biomechanics, and has 11 peer-reviewed journal publications and over 30 conference proceedings. She has taught as an instructor, adjunct professor, and guest lecturer in five major universities, including Columbia

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Colonel Grant Crawford, is an Associate Professor and the Director of the Mechanical Engineering Program at the United States Military Academy. He graduated from West Point in 1985 with a Bachelor of Science in Mechanical Engineering. He earned a Master of Science in Aerospace Engineering from the Georgia Institute of Technology in 1994 and a Ph.D. in Aerospace Engineering from the University of Kansas in 2004. He has taught courses in aeronautics, thermal-fluid systems, heat transfer, computer-aided design, and aerospace and mechanical engineering design. He is a licensed Professional Engineer and is a rated pilot.

Colonel Lynn Byers is the Director of the Design Group within the Mechanical Engineering Program at the United States Military Academy. She graduated from West Point in 1987 with a Bachelor of Science in Mechanical Engineering. She earned a Master of Science in Aerospace Engineering from The Pennsylvania State University in 1997 and a Ph.D. in Aerospace Engineering from The Pennsylvania State University in 2006. She has taught courses in aeronautics, dynamics, vibrations, computer-aided design, thermal-fluid systems, and aerospace and mechanical engineering design. She is a licensed Professional Engineer and is a rated pilot.