An Investigation of Learning Style and Discipline in a Human Factors Course

Mark C. Schall Jr.[1], Michelle L. Rusch [1], Geb Thomas [1], John D. Lee [2]

[1]*University of Iowa*, [2]*University of Wisconsin*

This study investigated adjustments made to learning materials for an Industrial Engineering Human Factors course at a public research university in the United States. Adjustments were made in an attempt to improve student comprehension of course content. Modifications included creating alternative homework assignments, design exercises, active classroom learning lessons, and lecture presentations to accommodate learning styles defined by Kolb's experiential learning theory. The same instructor taught the course before and after adjustment. Performance scores (e.g. homework, quizzes, exams) were used to evaluate whether or not the changes in course materials were associated with an improvement in student comprehension of material. Results suggested that while the adjusted materials educated all learning styles similarly, they did not significantly improve student performance. Significant differences were found across various disciplines; however, adjustments reduced these differences over the course of the semester.

INTRODUCTION

To become a competent human factors engineer, students must develop a broad knowledge of many disciplines (Liu, Baskin, Greene, & Frederick-Recascino, 2005; Wickens, Lee, Liu, & Gordon Becker, 1997). In doing so, students become more properly equipped to develop and deploy human-centered systems (Guerlian, Hayes, Pritchett, & Smith, 2001).

It has been suggested that to achieve optimal instruction, materials should be adjusted to accommodate an individual's learning style (Felder & Silverman, 1988). "The term 'learning styles' refers to the concept that individuals differ in regard to what mode of instruction or study is most effective for them." (Pashler, McDaniel, Rohrer, & Bjork, 2009, pg. 105). Many learning styles have been defined and classified by a variety of researchers with varying degrees of acceptance. Kolb's (1984) experiential learning theory is a well established model of learning that provides clear mechanisms by which students learn and educators can aim to teach (Abdulwahed & Nagy, 2009).

Kolb's theory proposes that effective learners build their knowledge through the development of four abilities: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) (Table 1) (Abdulwahed & Nagy, 2009; Harris, Sadowski, & Birchman, 2006; Kolb, 1985; Lamberski, 2002; Zanich, 1991).

Table 1. Kolb's Four Learning Abilities

Ability	Description
CE	Open involvement in new experiences
RO	Reflection on experiences from many perspectives
AC	Integration of observations into logical theories
AE	Application of theories to solve problems

The multi-disciplinary nature of an engineering human factors course creates a situation in which training all learning abilities and styles produces the best results (Guerlian et al., 2001). Students from many disciplines commonly participate in human factors courses (e.g., engineering, the liberal arts). A challenge of teaching these diverse populations is a difference in expected course structure. Often, engineering courses are structured on hands-on learning experiences that involve creating and constructing. Students from the liberal arts are typically more accustomed to a lecture based class that involves understanding theoretical concepts.

The objective of this study was to incorporate alternative learning approaches into existing course materials at a public research university in an effort to improve student comprehension and to accommodate for all learning styles across different disciplines. Three primary research questions were investigated to evaluate whether changes in materials were associated with an improvement in the quality of education. First, did students in the post-adjustment course perform significantly better than students in the pre-adjustment course? Second, did the adjusted materials teach all learning styles and disciplines similarly as described by Kolb's experiential learning theory? Third, did student perception of the course improve as a result of the changes?

Three constructs were examined to answer these research questions: student performance, learning style inventory scores, and satisfaction. It was hypothesized that the adjusted materials would significantly improve student performance when comparing post-adjustment student scores with pre-adjustment student scores. It was also expected that adjusted materials would accommodate all student-learning styles and disciplines similarly and that student satisfaction of the course would increase following the changes. For brevity, from here on forth the pre-adjustment class will be referred to as year one and the post-adjustment course referred to as year two.

METHODS

Participants

A total of 87 students participated in this study (year one = 44 students; year two = 43 students). All students were pursuing a degree in a human factors related field such as industrial engineering or psychology. Year one had six graduate students and year two had one graduate student. Ninety-one percent of year two students completed the Kolb LSI for learning style assessment.

Material Adjustments

While Kolb's four learning abilities are well established, the teaching tools that best map to each learning ability are debatable. Table 2 shows two examples of ways teaching tools have been mapped to different learning abilities.

Table 2. Teaching Tool Mapping

Ability	(Hartman, 1995)	(Bechter, 2008)
CE	Design Exercises & Labs	Design Exercises
RO	Project Logs & Reports	Lectures
AC	Lectures & Theory Papers	Lectures
AE	Homework & Case Studies	Design Exercies & Homework

Without a consistent basis for mapping educational tools to the four learning abilities, we chose to map our teaching tools in the same manner as Hartman (1995). We felt that this design was most closely associated to Kolb's learning abilities and the existing teaching tools that were being used.

Lecture Materials. Research has shown that due to the passive nature of most lectures, student attention has a tendency to drop within the first 10 to 30 minutes (Young, Robinson, & Alberts, 2009). As such, lecture PowerPoints were adjusted in year two to ensure each had a clear focus and were modified to include "focus blanks". "Focus blanks" are holes that take the place of key words, figures, or units that are needed by students to fully understand a lecture topic. During lectures, these keywords, figures, and units made animated entrances into each slide to generate attention. Students who attended lecture were required to actively listen and participate in class to gain the valuable information. These adjustments were included to benefit students with CE and AE learning strengths as these students tend to struggle to maintain attention during lectures.

Case Studies and Homework. Homework provides students an opportunity to practice the skills taught to them in the classroom. Research has suggested that students who find their homework interesting and well selected tend to be more motivated to complete their assignments (Dettmers, Trautwein, Lüdtke, Kunter, & Baumert, 2010).

In year one, case study readings from the text *Set Phasers on Stun* (Casey, 1993) were assigned to students on a weekly basis. The textbook includes a compilation of true stories of system design oversights that led to disastrous consequences relevant to human factors topics. Each case study required a student to read a specified case study, write a short summary of the story, and complete an analysis of the human factors mistakes made or not considered by designers. The students were asked to also include a short list of proposed design solutions that could have been integrated in the initial design of the system to potentially prevent the accident. The assignments provided the students an opportunity to practice their oral and written communication skills that led to many class discussions.

Year two of the course required completion of the same case study assignments. In addition, small groups of 4-5 students were created and each was assigned a case study to present to the class. Each group was required to create a PowerPoint presentation that included a summary of the case study, an analysis of the causes for the disaster, and suggested solutions that addressed the causes. Each group was also required to present a visual example (i.e., a picture of a current product that could have been used to prevent a cause of the disaster) to illustrate their solutions. Several questions or discussion topics were to be included in the presentations to instigate discussion on relevant Human Factors concepts.

Each case study assignment was further adjusted to contain an applied practice problem that was completed and turned in along with the case study summary and evaluation. These homework problems were added to provide students with a chance to further practice the mathematical based theories and concepts taught in the classroom (e.g. Fitt's law, illumination and reflection, the Hick Hyman law, etc.).

The overall goal of these adjustments was to promote active learning and abstract thinking to benefit students with RO and AC learning strengths. Rather than consistently have the professor simply deliver answers in which the students passively absorbed information, this approach helped facilitate long-term retention of information while students developed and improved their problem-solving skills as a result of having more direct involvement.

Design Exercises. Design exercises are fundamental to a engineering education as they allow students to develop problem-solving skills through innovative exploration (Garrod, 1989). Design tasks are important for students as they involve goal and constraint driven processes that teach students to view generic tasks as problem solving accompanied with uncertainty (Guerlian et al., 2001).

In year one, a series of four design exercises were completed by groups of students in the course. All of the design exercises covered recently taught theories and concepts. Each assignment was designed to build upon its predecessor, ultimately ending in an end of the semester presentation of a product designed by students. The first version of the course required students to design a home thermostat application that could be included as an iPhone application. Each design assignment required the composition of a four to five page report. Also, each group's final design was presented to the class.

Year two included a similar series of design deliverables. However, the final product designed by students was no longer an iPhone application, but rather a portable media player that could be used in the airline industry. Additionally, a new small design project was added to the front-end of course materials. This design exercise was given during the first two weeks of class and was designed to get students interacting with their group members earlier than in past semesters. Also, this exercise helped illustrate to students the difficulty of designing a product when human factors tools and principles are not considered. The additional design project was designed to benefit students with RO and AC learning strengths as it created an opportunity for these students to better reflect on their progress throughout the semester.

Quizzes. Quizzes are generally used as a means to evaluate student comprehension of a topic. Researchers have administered on-line weekly quizzes in an attempt to make students work more punctually and seriously on their weekly laboratory assignments (Woit & Mason, 2000). Quizzes were adjusted to an on-line format to take advantage of this idea.

In year one, quizzes were administered roughly every three weeks. The material included in each quiz generally covered the three previous chapters studied. Students were expected to complete the quizzes outside of class without using their textbooks, class notes, or assistance from fellow classmates. Unfortunately, it was often found that students would disregard these expectations and use those resources to ensure that they received a "good" grade. As a result, students were not benefiting much from the quizzes. Rather than study and practice the material needed to do well on each quiz, students were only practicing their ability to find answers using their resources. Ultimately, this would hurt students on the day of a test as these resources were not available and knowledge had not been sufficiently retained for future recall.

In year two, quizzes were similarly administered every three weeks and included material relevant to the previous three chapters studied. However, the quizzes were presented in an on-line timed format. It was the hope of the researchers that students would be more likely to study the quiz material prior to taking the quiz with the new time constraints. Students now had a smaller opportunity to cheat by using their friends and resources due to the limited timeframe.

In addition to the positive impact of the new time constraints, by issuing the quizzes on-line and by allowing the computer to automatically grade the student responses, students received direct feedback on their answers. This format provided all students regardless of learning strength a better opportunity to review their progress to date and immediately alter the way they completed their work.

Exams. Two midterm examinations and a final comprehensive examination were administered in both year one and year two. Each midterm exam included information on the material covered in the six weeks prior to that exam. The final exam was given at the end of the semester and was designed to test the student's overall understanding of the concepts and methods presented in the textbook, lectures, and all accompanying course materials. The decision to not alter the examination format provided a means to compare year one and year two versions of the course.

Procedure

The research study was presented to the year two class at the beginning of the semester. A neutral team member explained the purpose of the research, distributed consent forms, and administered a hard copy of the Kolb LSI. The lead researchers (who taught the course) were not present in the classroom at this time. The surveys and consent forms were distributed and completed in the classroom only at that time.

Each subject was assigned a study identification number prior to completing the Kolb LSI. The study identification number was used to link each subject's survey responses to their course scores for analysis following completion of the course. Analysis and review of the information was conducted at the end of the semester after final grades had been assigned. All survey material was concealed until the end of the data collection period. This protective measure was taken to ensure that student grades could not be affected by the students' decision to participate. Students completed no other tasks outside of typical classroom activities during the study.

Analysis

Likelihood-based methods were used to fit linear mixed models to analyze the data. These models were used to test for differences between years, relationships to Kolb learning styles, and disciplines (colleges) that the students were associated. The researchers looked for relationships between learning style scores (i.e., from the student's Kolb LSI) and student course performance scores (i.e., homework, quiz, and exam scores). Differences in least squares means (LSM) were analyzed for significant differences in LSI scores.

Two of the four learning styles from Kolb's experiential learning theory, *converger* (ACAE) and *diverger* (CERO), were used as two main statistical categories. The two other learning styles, assimilator and accommodator, were classified under a separate category labeled *Other*. These three categories were chosen as they included all students in roughly equal percentages and because the Kolb LSI generally filters engineering students into the *converger* (ACAE) and *diverger* (CERO) learning styles. All students were members of the College of Engineering (COE) or the College of Liberal Arts and Sciences (CLAS). These two colleges were used distinguish student discipline. Student classification level (i.e. graduate, senior, junior, etc.) was also analyzed.

RESULTS

Results from a linear mixed model comparison of student performance by year showed significant performance differences when comparing students based on discipline and classification. Significant differences for discipline were found in homework scores ($F(1,80)=8.96$, $p<0.01$), quiz scores ($F(1,80)=9.04$, $p<0.01$), exam one scores ($F(1,80)=9.56$, $p<0.01$), exam two scores ($F(1,80)=4.64$, $p=0.03$), and overall course scores ($F(1,80)=14.58$, $p<0.01$). Significant performance differences for classification were found for exam one scores ($F(1,80)=2.66$, $p=0.05$), final exam scores ($F(1,80)=3.00$, $p=0.04$), and overall course scores ($F(1,80)= 5.06$, $p<0.01$). No significant differences were found when comparing students by year. Figure 1 shows student differences by discipline. Students who belonged to the COE were found to perform eight or more points higher on most course materials than students who belonged to the CLAS.

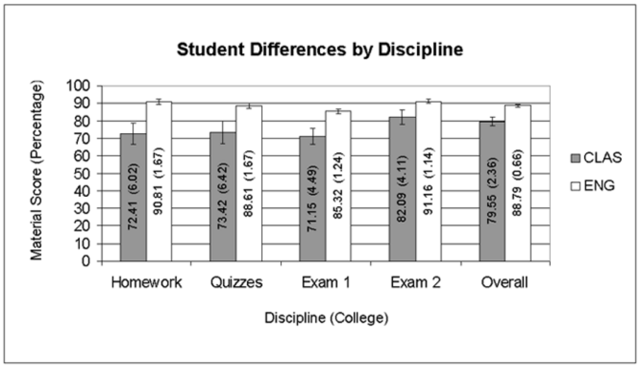

Figure 1. Student differences by discipline (CLAS = College of Liberal Arts and Sciences; ENG = College of Engineering).

Comparisons between the post-adjustment class performances with student LSI scores showed no significant differences in homework (F(1,33)=0.72, *p*=0.40), projects (F(1,33)=0.04, *p*=0.84), quizzes (F(1,33)=0.06, *p*=0.81), exam one (F(1,33)=0.26, *p*=0.61), or exam two (F(1,33)=0.38, *p*=0.54). There was an interesting effect (F(1,33)=3.12, *p*=0.06) for the LSI/gender interaction term for the final exam.

Figure 2A shows student differences for LSI category by gender for the year two final exam. The results showed that the *Other* Female category and the *Other* Male category were significantly different (*p*=0.04). The LSM for the CERO (*diverger*) Female condition was also significantly different from the *Other* Female condition (*p*=0.02). Figure 2B shows student differences for material by LSI category. The results showed no significant differences between LSI categories for each material type (p>0.98).

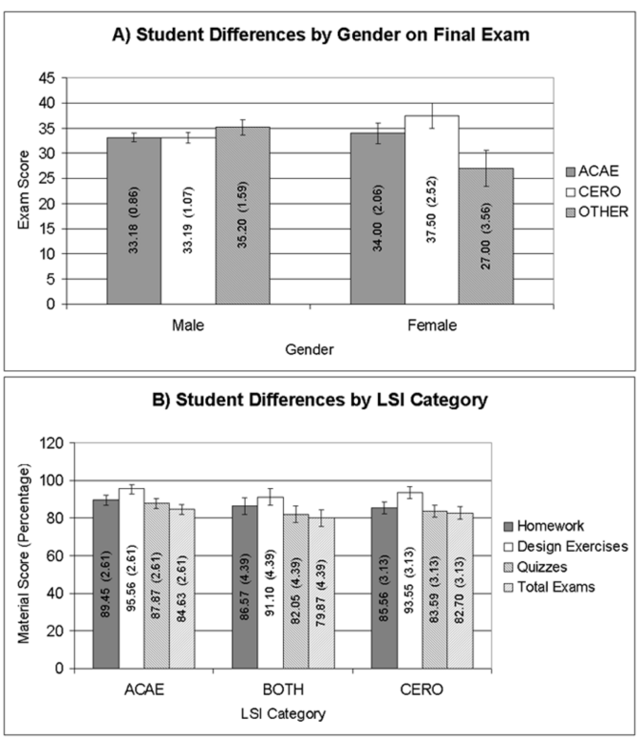

Figure 2. Shows student differences for A) LSI category by gender on the year two final exam, B) material by LSI category.

Differences of LSMs were compared for two course evaluation questions completed at the end of the semester to determine student opinions of the changes. The first question asked if students felt they had acquired a basic understanding of the subject area. The difference in LSMs showed no significant difference between years one and two of the course (*p*=0.66). The second question asked whether students felt the instructional methods and materials contributed to their learning. Again, the difference in LSMs showed no significant difference between years one and two of the course (*p*=0.54).

DISCUSSION

The primary objective of this study was to investigate adjustments made to course materials in an engineering human factors course. Modifications included creating alternative homework assignments, design exercises, active classroom learning lessons, and lecture presentations to accommodate learning styles defined by Kolb's experiential learning theory. The adjustments were expected to enhance student understanding of course content, which would in turn improve student grades on all assignments, examinations, and overall course grades. Results indicated that the course material adjustments were relatively insignificant. Students who took the course prior to the adjustments (year one) did just as well as students who took the course after the alterations were made (year two).

Significant differences in student performance scores were found when comparing students based on discipline. Students who belonged to the COE performed better overall in the course and on course materials than students who belonged to the CLAS. This is an important discovery as human factors courses are multi-disciplinary in nature and are not generally isolated to engineering students. It is interesting to note that students who belonged to the CLAS improved their scores throughout the semester eventually meeting the performance scores of students in the COE as observed by gradual improvements on exams. These improvements could be attributed to the material adjustments; however, lack of data on CLAS students limits our ability to draw considerable conclusions. Inclusion of different learning approaches not typically included in an engineering course merits further investigation.

Significant differences in student performance scores were also found when comparing various levels of classification. Students performed better as their classification level increased. For example, graduate students performed five, six, and seven points better than senior, junior, and sophomore level undergraduate students respectfully in their overall course percentage. This is not surprising as engineering graduate students are expected to have had more experience in the field of human factors due to their undergraduate education than students with an undergraduate classification.

Significant differences between year one and two were found on the final exam for the LSI component of this study. Significant differences were found between the *Other* Female category and the *Other* Male category and between the *Other* Female category and CERO (*diverger*) Female category. These differences were likely due to the *Other* Female category (1 student) being an outlier. Comparing years and LSI scores showed that there were no gender differences. Therefore, the fact that the *Other* Male and *Other* Female categories were significantly different was most likely due to another factor other than gender. The difference was likely due to the one female student in the *Other* Female category having been an outlier. This is likely the case for the *Other* Female and CERO (*diverger*) Female difference as well.

No significant differences were found for student evaluations, the modifications had little if any effect on student attitudes toward the course. With no consistent significant differences being found between the two versions of the course, adjustments in materials did not appear to have diminished from the quality of education. This potentially adverse outcome was a concern as adjustments in course materials were being made to an active course. In addition, with no significant differences being found for the LSI category, the materials used appeared to have accommodated all types of learners. This fact is of value to the university as it shows that all student-learning styles are being taught relatively similarly in the engineering human factors course.

CONCLUSION

The authors acknowledge that this study includes some methodological limitations and design flaws that challenge internal consistency. For instance, without LSI information from year one of the course, it is unknown whether learning style distribution is equivalent between year one and year two students. Further, it can be argued that the material adjustments are not clearly linked to the learning abilities they were supposed to benefit. Regardless, the authors feel that this work represents a good faith effort to identify materials that will work for a diverse field of human factors students.

Universities can use this course structure and the results of this study as a foundation for developing and/or improving their human factors curriculum. Our results show that given a comparable course structure and content to that used within this study, differences across disciplines in a human factors course could potentially be reduced.

REFERENCES

Abdulwahed, M., & Nagy, Z. K. (2009). Applying kolb's experiential learning cycle for laboratory education. *Journal of Engineering Education*, *98*(3), 283-293.

Bechter, C., & Esichaikul, V. (2008). Using kolb's learning style inventory for e-learning personalization. *IADIS International Conference on Cognition and Exploratory Learning in Digital Age (CELDA),* 121-128.

Casey, S. M. (1998). *Set phasers on stun: And other true tales of design, technology, and human error, 2nd Edition.* Santa Barbara, CA: Aegean Publishing Company.

Dettmers, S., Trautwein, U., Lüdtke, O., Kunter, M., & Baumert, J. (2010). Homework works if homework quality is high: Using multilevel modeling to predict the development of achievement in mathematics. *Journal of Educational Psychology, 102*(2), 467-482.

Felder, R.M. & Silverman, L.K. (1988). Learning and Teaching Styles in Engineering Education. *Engineering Education, 78*(7), 674-681.

Garrod, S. A. R. (1989). Conducting a design workshop in the classroom. *Frontiers in Education Conference, 1989,* 213-216.

Guerlian, S., Hayes, C., Pritchett, A., & Smith, P. (2001). Exercises / Techniques for teaching cognitive systems engineering. *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting*, 453-457.

Harris, L. V., Sadowski, M. A., & Birchman, J. A. (2006). A comparison of learning style models and assessment instruments for university graphics educators. *Engineering Design Graphics Journal, 70*, 6-14.

Hartman, V. F. (1995). Teaching and learning style preferences: transition through technology. *VCCA, Journal*, 9(2), 18-20.

Kolb, D. (1984). Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice-Hall.

Kolb, D. (1985). Learning style inventory. Boston, MA: McBer and Company.

Lamberski, R. J. (2002). *Kolb learning style inventory.*, 2009, from http://www.coe.iup.edu/rjl/instruction/cm150/selfinterpretation/kolb.htm

Liu, D., Baskin, A., Greene, F., & Frederick-Recascino, C. (2005). Designing human factors courses with a human factors mind. *Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting,* 783-787.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2009). Learning styles: Concepts and Evidence. *Psychological Science in the Public Interest, 9*(3), 105-119.

Wickens, C. D., Lee, J. D., Liu, Y., & Gordon Becker, S. E. (1997). *An introduction to human factors engineering* (2nd Edition) Prentice Hall.

Woit, D., & Mason, D. (2003). Enhancing student learning through on-line quizzes. *Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education,* Reno, Nevada, 137-141.

Young, M. S., Robinson, S., & Alberts, P. (2009). Students pay attention: Combating the vigilance decrement to improve learning during lectures. *Active Learning in Higher Education, 10*(1), 41-55.

Zanich, M. L. (1991). *Learning styles / teaching styles.* Unpublished manuscript. Indiana University of Pennsylvania, Teaching Excellence Center, Indiana, PA.