

The Efficacy of Learning in a Blended Learning Environment for Industrial Design Education

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The ID program at NCSU faces a number of challenges that are common to small academic units in an era of shrinking resources. These include problems of physical space, scheduling conflicts, and the need to increase *full-time equivalents* (FTEs). According to the NCSU Department of Industrial Design Chair, Bryan Laffitte (personal communication, Mar. 26, 2007), "it is hard to find physical spaces to hold class in the College of Design that are without noise pollution and provide a substantial amount of space to hold a project review". Then there are course scheduling conflicts which make it very hard to reserve rooms to hold classes and to offer classes at practical times of day that best suit more effective student learning (B. W. Laffitte, personal communication, Mar. 26, 2007). FTEs also impact the industrial design curriculum. A FTE or full-time equivalent is a measure of the number of students attending NCSU full-time. An undergraduate student carrying at least 12 credit hours or a graduate student carrying at least 9 credit hours constitute 1 FTE (K. Helm, personal communication, Mar. 26, 2007). The NCSU Provost monitors the number of FTEs that instructors teach because he wants the university to run efficiently, so each faculty member needs to carry an appropriate teaching load (K. Helm, personal communication, Mar. 27, 2007).

A method of instruction that could improve FTE production while not adding to the burden of class space is blended learning. Janet MacDonald (2006) described *blended learning* as "the introduction of online media into a course or program, while recognizing that there is merit in retaining face-to-face contact and other traditional approaches to supporting students." The "online media" that MacDonald (2006) mentioned can behave in two ways, in an asynchronous manner or in a synchronous manner. Operating in an *asynchronous* manner means that "two or more parties communicate via email or related technologies in a time-independent manner" (Collis, 1996). Communicating in a *synchronous* way means that "two or more parties are communicating at the same time, though not necessarily in the same place"; e.g., using AOL Instant Messenger to communicate with someone (Collis, 1996). Blended learning can be used to instruct more students and make learning more effective by using online supplements to NCSU industrial design courses, thus reducing the issues of finding physical space to hold classes and reducing course scheduling conflicts. Plus, flexibility would be provided for students to learn outside of the classroom. This evolves into the research questions of my experiment: Is blended learning in industrial design education at NCSU effective? Specifically, do industrial design students at NCSU instructed in a blended learning environment learn more than NCSU industrial design students instructed in the traditional learning environment? My hypothesis (alternative hypothesis H_1) is that industrial design students instructed in a blended learning environment will learn more than industrial design students instructed in the traditional learning environment. The null hypothesis (H_0) is that there will be no difference between the industrial design students instructed in the blended learning environment and those instructed in the traditional learning environment. The independent variable (2 levels) of my experiment is the learning environment, traditional and blended learning. The dependent variable is the amount of learning that takes place in each learning environment, as measured by a pretest, a posttest, and drawing evaluations.

SAMPLE. Twelve industrial design students from NCSU ($N = 12$) were selected from the fall 2006 semester class roll of ID 318 Section 002, also referred to as Ideation 1. Prior to the participant selection the Ideation 1 class roll was randomized. The participants consisted of 6 graduate students, 1 senior, 1 junior, 1 sophomore, 2 freshmen, and 1 continuing education student. In terms of gender, the sample consisted of 3 females and 9 males. To create the control group ($n = 6$) and experimental group ($n = 6$) for the experiment, the 12 participants were randomly assigned to either group. The control group included 5 graduate students and 1 continuing education student; 3 females and 3 males. The

experimental group was made of 1 graduate student, 1 senior, 1 junior, 1 sophomore, and 2 freshmen; all males.

APPARATUS. The members of the control group used grayscale markers and color markers, marker paper, and dry pastels. For hardware each member of the experimental group used a Dell PC Optiplex GX 280 or an Apple Macintosh G5 and grayscale markers, color markers, marker paper, and dry pastels. In directing the experimental class I used a *Wacom Cintiq*, which is a LCD interactive pen display that can be used to draw digitally, and a headset microphone to administer the treatment. The software used was Macromedia Breeze v5 and Autodesk AliasStudio v13. Macromedia Breeze, rebranded as Adobe Acrobat Connect Professional, is a “scalable, highly customizable, extensible web conferencing solution” and it produces telepresence (Adobe Systems Incorporated, 2007). *Telepresence* is characterized by Walker & Sheppard (1999) as “the enabling of human interaction at a distance, creating a sense of being present in a remote location.” Macromedia Breeze is used for real-time video and audio conferencing on the internet and it possesses whiteboard capabilities. A *whiteboard* is an “on-screen workspace viewed by everyone in the conference and can be annotated by all in the conference” (Parke, 1999). Macromedia Breeze is a *multi-point* online communications solution because it facilitates communication between multiple users in multiple locations (Parke, 1999). The software also possesses *scalability* which Cordell et al. (1999) defines as the ability for a conferencing program to utilize available resources to support online conferencing on a small scale as well as a large scale, while maintaining the quality of service. Autodesk AliasStudio, a surface modeling CAD software program that has digital drawing capabilities, was also used to administer the treatment.

PROCEDURE. Preliminary preparation for the experiment began with meetings between the class instructor and I. During these meetings we discussed the three learning objectives for the participants of the experiment. These learning objectives were for the participants to be able to correctly choose three color markers that represented all the values of a given hue, to render matte surfaces using grayscale markers, and render shiny surfaces using a trio of color markers. The meetings also involved Bryan Laffitte demonstrating how to teach the learning objectives to the experiment participants. The participants’ mastery of the three learning objectives would be evidenced by their ability to replicate a concept drawing of a pencil sharpener using grayscale markers and color markers. I was taught how to draw the pencil sharpener concept drawing.

A website was designed to provide the participants in both groups with information to prepare them for the experiment. The information included course meeting times and technical setup instructions for Macromedia Breeze.

A pretest/posttest control group design was used for the experiment where the control group was instructed in the traditional industrial design learning environment and the experimental group was taught using blended learning. The pretest and posttest both consisted of 10 questions based on the three learning objectives of the experiment. The posttest was different from the pretest but possessed the same difficulty level as the pretest. Since industrial design is inherently subjective and the participants produced drawings as a part of the experiment, an evaluation of their drawings was necessary.

After the preliminary preparation for the experiment I worked with the control group. I introduced myself to the participants of the control group and administered the pretest using Macromedia Breeze’s learning management system capabilities. After all of the participants completed the pretest I began the drawing lecture. The control group’s drawing lecture was taught in the regular Ideation 1 classroom, which was made up of seven tables that seated six students apiece. At the beginning of the lecture each participant received a copy of the pencil sharpener concept drawing and they were asked to draw it to the best of their ability using grayscale and color markers along with dry pastels, this was the *prelecture drawing*. Next, using color markers that I had brought with me, I trained the participants to identify color markers that would make a good color marker trio that represented the light, medium, and dark values of a particular hue. Instruction was given about rendering matte surfaces using grayscale markers, the general technique was taught, and then the control group was shown how to render the matte surface in the pencil sharpener concept drawing. Similarly, the general technique for rendering shiny materials was demonstrated, and then the control group was shown how to render the shiny surface in the pencil

sharpener concept drawing. Lastly, the method for using dry pastels was demonstrated using the pencil sharpener as a practical example. Following the demonstrations of the preceding drawing techniques, a physical representation of the pencil sharpener in the concept drawing was displayed to the control group and they were allowed to study it, observing how light and shadows defined the form. Finally, the control group was asked to recreate the pencil sharpener concept drawing again, this was the *postlecture drawing*. I collected the participants' prelecture and postlecture drawings and administered the posttest to the control group.

Subsequently, I began working with the experimental group, starting with an introduction to Macromedia Breeze in a computer lab. They were "walked" through the technical setup of a Macromedia Breeze web conference, all technical questions that the participants had were answered, and a time for the online synchronous drawing lecture was confirmed. Also, everyone was informed of the required materials for the online drawing lecture. Then the pretest was administered to experimental group via Macromedia Breeze. At the beginning of the drawing lecture web conference I made sure that everyone logged in properly and that sound was being transmitted to all of the participants. I used audio to communicate with the participants and they used Macromedia Breeze's chat window to communicate with me. Next, the pencil sharpener concept drawing was displayed and the participants were asked to draw it to the best of their abilities using grayscale markers, color markers, and dry pastels. This drawing was the prelecture drawing for the experimental group. Afterwards, I began using a PowerPoint presentation, formatted for Macromedia Breeze, to teach the experimental group how to identify a trio of color markers that accurately represented the values of a specific hue. The participants were taught about the use of light transitions and highlights in drawing. Using the digital drawing tools in Autodesk AliasStudio and a Wacom Cintiq, the experimental group was taught how to render matte surfaces, how to render shiny materials, and how to use dry pastels. During the instruction general rendering techniques were demonstrated and then the components of the pencil sharpener concept drawing were used as practical applications of the various rendering techniques. An animated 3D reference of the pencil sharpener was displayed for the experimental group to study. The animated 3D reference had a matte and shiny surface similar to the concept drawing. Lastly, the participants were told to recreate the pencil sharpener drawing again, this was the postlecture drawing. Then the posttest was administered, and the prelecture and postlecture drawings were collected at the next face-to-face Ideation 1 class.

The pretest and posttest results for the control and experimental groups were collected and analyzed using descriptive and inferential statistics. The prelecture and postlecture drawings were collected, randomized, and evaluated by the instructor of Ideation 1 using a 5 point Likert scale that assessed the quality of the drawings using the three learning objectives for the drawing lectures.

STATISTICAL PROCEDURE. The gain score was calculated for every participant in the control group and the experimental group, then the *mean gain score (M Gain Score)* was calculated for each group. To determine the mean gain score each participant's posttest score is subtracted from their pretest score, the difference is called the *gain score*. Once all of the control group and experimental group participants' gain scores have been calculated each group's gain scores are averaged together. This is how the mean gain score is derived. The mean gain score indicates the amount of learning that has taken place in each group. Also, along with other descriptive statistics, the *standard deviation (SD)* was calculated for each group. The standard deviation indicates how the gain scores for each participant vary in regard to their group's mean gain score.

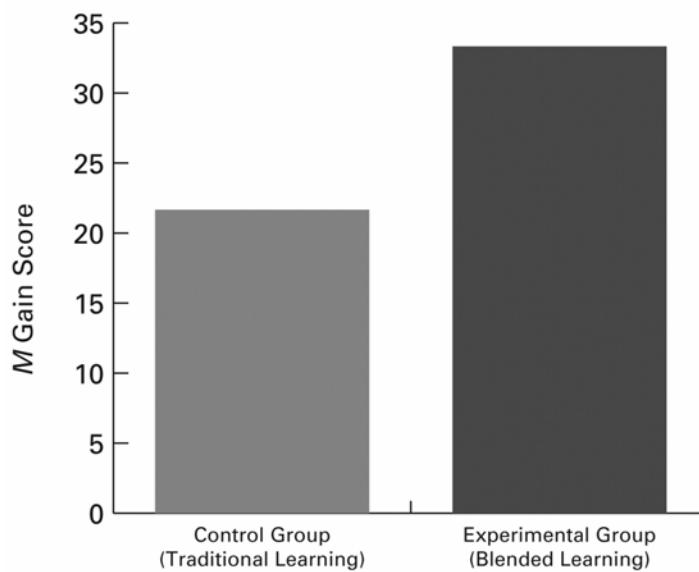
Due to the small sample size used in this experiment, tests of statistical significance were not used. Instead effect size (ES) was used. According to Jacob Cohen (1988) *effect size* is "the degree to which the null hypothesis is false", which can also be interpreted as the amount of difference between two groups. Effect size is not affected by the sample size of an experiment whereas statistical tests of significance are. According to Robert Rosenthal (1999) using statistical tests of significance for studies with small sample sizes will lead to "nonsignificant results and failure to detect the effect that would have been detected with a larger sample size". Using effect size will allow the researcher to find interesting

¹ The physical representation of the pencil sharpener concept drawing was a 3D computer model printed on a Dimensions 3D BST Printer.

relationships in studies with small sample sizes (Rosenthal, 1999). The particular measure of effect size that was used to analyze my experiment's data was Cohen's *d*. Cohen's *d* is the "degree of departure from the null hypothesis of the alternative hypothesis, or the ES we wish to detect" (Cohen, 1988). *d* can be interpreted in three ways, *d* = .2 indicates a small effect size, *d* = .5 indicates a medium effect size, and *d* = .8 indicates a large effect size.

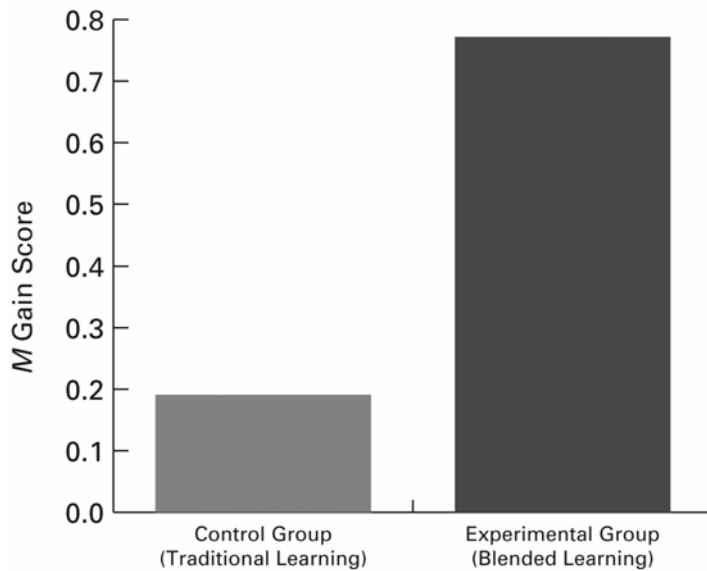
RESULTS. The pretest/posttest mean gain score of the experimental group was higher than the mean gain score of the control group. The mean gain score of the experimental group was 33.333 (SD = 13.662) and the mean gain score for the control group was 21.667 (SD = 13.291). An effect size of .866, which is large, was found between the experimental and control groups. This indicates that there was a 52.6% overlap and a 47.4% nonoverlap of the experimental group's and the control group's gain scores (see Figure 1).

Figure 1. Graph of Pre-Test/Post-Test Mean Gain Scores.



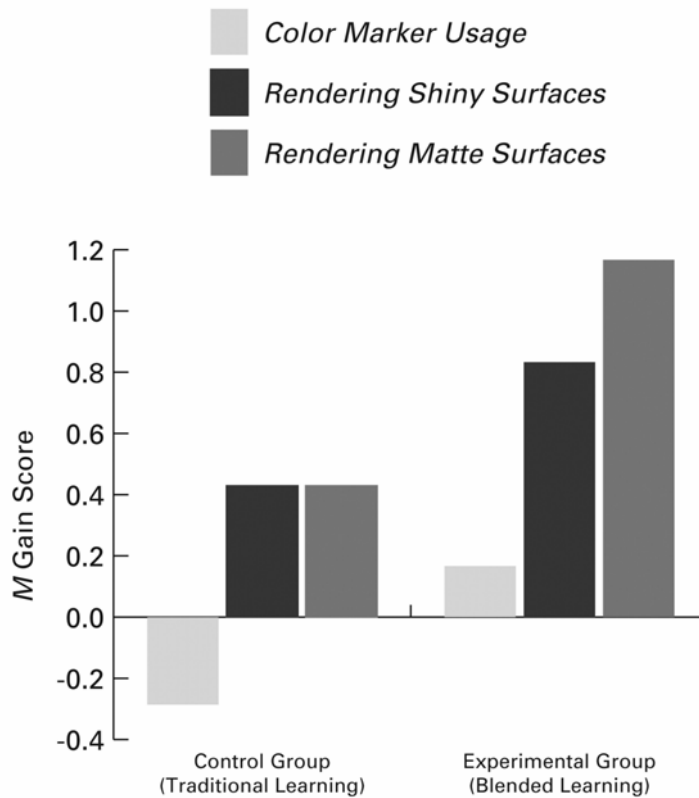
The experimental group's mean gain score was higher than the control group's on the overall evaluation of the prelecture and postlecture drawings. The mean gain score for the treatment group was 0.722 (SD= 1.182) and the control group's was 0.191 (SD=1.016). A medium effect size of .438 was found, which signifies that there was a 72.6% overlap and a 27.4% nonoverlap of the treatment and control groups' gain scores (see Figure 2).

Figure 2. Graph of Drawing Evaluation Mean Gain Scores.



The prelecture and postlecture drawings of both groups were also evaluated according to the three learning objectives of the drawing lecture; i.e. the participants' abilities to use a color marker trio that represented all values of a specific hue, to render matte surfaces, and to render shiny materials. The mean gain scores for the experimental group and the control group to use the ability to use the appropriate color marker trio were 0.167 (SD = 1.182) and -0.286 (SD = 0.756) respectively. The effect size found was .588, a medium effect size that indicated a 67% overlap and a 33% nonoverlap of each group's gain scores (see Figure 3). In terms of rendering matte surfaces, with a mean gain score of 1.167 (SD = 1.169) the experimental group outperformed the control group, which had a mean gain score of 0.429 (SD = 1.618). The effect size between the two groups was .37, a small effect size with a 78.7% overlap and a 21.3% nonoverlap of both groups' gain scores (see Figure 3). Lastly, when the two groups were evaluated on their ability to render shiny surfaces, the experimental group's mean gain score of 0.833 (SD = 1.722) was higher than the control group's mean gain score of 0.429 (SD = 0.976). The small effect size of .207 that was found alluded to an 85.3% overlap and a 14.7% nonoverlap of both groups' gain scores (see Figure 3).

Figure 3. Graph of Drawing Evaluation Breakdowns.



DISCUSSION. For the pretest and posttest data the mean gain score of the experimental group is larger than the mean gain score of the control group. This demonstrates that the experimental group learned more about choosing and using the appropriate color markers to make a trio, rendering matte surfaces and shiny surfaces, and rendering the form and volume of materials. The effect size is .866 and the experimental group had the higher mean gain score, which means that the experimental group is largely different from the control group in terms of the amount of knowledge learned about rendering materials with color, therefore an effect exists and my null hypothesis can be rejected. This difference is probably due to the use of blended learning and the reflective aspects of the online lecture that the experimental group was given. When the experimental group was taught the drawing lesson, a PowerPoint presentation that consisted of lecture notes was presented to them that covered all of the lecture material as I discussed it, which allowed the participants to both see and hear the information. The control group was taught in the traditional manner of industrial design education and thus did not receive any visual lecture notes and only received the lecture in an auditory manner. It also stands to reason that the experimental group, which was made up of 5 undergraduate students and 1 graduate student, learned more about using colored markers to render materials because they had less previous knowledge about drawing to conflict with the new knowledge that they were learning, and perhaps because they were much younger.

The prelecture drawings and the postlecture drawings of both groups were rated using a 5 point Likert scale. The mean gain score of the drawings of the experimental group is higher than that of the control group and a medium effect size of .438 exists. This indicates that there was a difference in the quality of the experimental group's drawings that is markedly noticeable. The difference between the two groups' drawings can be attributed to the way that the experimental group's learning environment differed from the learning environment of the control group. The experimental group had a computer screen for each participant to look at the online lecture whereas the control group, being taught in the traditional industrial design learning environment, had to crowd around the teacher to observe the lecture. The effect size of

the students' abilities to render shiny surfaces is small, so there is not much of a difference between the experimental group and the control group in this area. However, there is a medium effect size that is found between the experimental group and the control group in terms of effectively using color markers to render materials. This could be due to the fact that the experimental group received lecture notes detailing the correct method of using colored markers and the control group was only told the methodology for using colored markers but received no material to reflect upon. Also, the experimental group was shown an animated 3D model of the pencil sharpener that they were supposed to draw after the lecture as opposed to the representation of the pencil sharpener that the control group was shown. Although a small effect is found between the experimental and control groups in the area of rendering matte surfaces, the mean gain score of the experimental group was much higher than the control group's, which provides evidence that the experimental group learned to render matte surfaces better as well.

The students in the experimental group provided written feedback about their experience in the blended learning environment. A few of the students were apprehensive about using the blended learning environment but their apprehension subsided once they were engaged in the online lecture. Most of the students liked learning in the blended learning environment because it was flexible and it was easy to maintain focus. Some students said that the drawbacks to using the blended learning environment were that they would have liked to have seen the instructor drawing on paper instead of digitally and they felt as if they had lost a little of the human connection because the instructor was not the main focus of their attention. Also, a few participants had problems with network connection *latency*, which is "the end-to-end delay of control messages and conference media" (Cordell et al., 1999).

CONCLUSION. The findings of this experiment provide evidence that the use of blended learning in industrial design education at NCSU is effective and does facilitate more learning than the traditional industrial design learning environment.

LIMITATIONS. This experiment has several limitations that need to be addressed. The sample size was small and not diverse. This can be accommodated in the future by using a bigger sample size that is stratified so that it accurately represents university classifications, ages, and genders. The observation period for the experiment needs to be longer. Also, different mixes of blended learning should be administered; e.g. face-to-face class time mixed with online learning or synchronous online learning mixed with asynchronous online learning. The participants' fluency with technology needs to be assessed at the beginning of the experiment to see how much they differ from each other in their technical abilities. The level of telepresence experienced by the experimental group needs to be evaluated subjectively, behaviorally, or physiologically. Due to the problems of intra-observer reliability more than one rater is needed for the evaluation of the pre- and postlecture drawings, for the purpose of criterion-related observer reliability.

IMPLICATIONS. There are several implications for practice that now exist as a result of this experiment. Other industrial design courses at NCSU can be turned into blended learning courses. Once this occurs students' personal learning environments can change; e.g. students could go from learning in a classroom to learning in their dormitory rooms due to the flexibility of blended learning. One use of blended learning with amazing potential would be industrial design studio courses with a collaborative online conferencing component that connects students with practitioners from all over the United States, and possibly the world, to share knowledge and ideas about industrial design. Thus, NCSU industrial design education and practice could be connected in an interactive way. As an additional benefit, industrial design courses could be held for working professionals as a means to update their skill sets and learn new information as they engage in lifelong learning.

REFERENCES

- Adobe Systems Incorporated. (2007) *Adobe—Acrobat Connect Professional—Enterprise Web Conferencing Software, Enterprise Web Conference, Enterprise Web Conferencing Solution*. Retrieved May 08, 2007, from <http://www.adobe.com/products/acrobatconnectpro/>.
- Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Collis, B. (1996) *Tele-learning in a digital world: The future of distance learning*. London, UK: International Thomson Computer Press.
- Cordell, P., Courtenay, M., & Rudkin, S. (1999) Conferencing on the Internet. In G. Walker & P. Sheppard (Eds.), *Telepresence*. Boston: Kluwer Academic Publishers.
- MacDonald, J. (2006) *Blended learning and online tutoring: A good practice guide*. Burlington, VT: Gower.
- Parke, I. (1999) "The evolution of conferencing." In P. Sheppard & G. Walker (Eds.). Boston: Kluwer Academic Publishers.
- Rosenthal, R. & Kramer, S. (1999) "Effect sizes and significance levels in small-sample research." In R. Hoyle (Ed.), *Statistical strategies for small sample research*. Thousand Oaks, CA: Sage Publications, Inc.
- Walker, G. & Sheppard, P. (1999) "Telepresence: The future of telephony." In P. Sheppard & G. Walker (Eds.), *Telepresence*. Boston: Kluwer Academic Publishers.