

The Evaluation of Alternate Learning Systems: Asynchronous, Synchronous and Classroom

V. Singh, M. Khasawneh, S. Bowling, X. Jiang, R. Master, and A. Gramopadhye¹
Department of Industrial Engineering
Clemson University
Clemson, SC 29634-0920

Abstract. Web-based asynchronous learning systems have revolutionized the learning environment. Rapid advances in computer technology, the Internet and transmission technology have created new opportunities for delivering instruction. It is anticipated that these technologies will dramatically change the way instruction will be imparted throughout the educational system. One example is asynchronous learning wherein instruction can be delivered at any place at any time on demand. If we are to use this new mode of delivering and receiving instruction, we need to fully understand its advantages and limitations to existing forms of delivering instruction. In response to this need, this paper describes a study conducted to evaluate the usefulness of delivering instruction asynchronously. The study compared three forms of instruction: classroom, synchronous and asynchronous using student subjects from an industrial engineering course. Results of this study throw new light into the usefulness of the Internet and asynchronous learning.

1. INTRODUCTION

Traditionally, learning and teaching have been built around the classroom environment wherein an instructor, using tools like a chalkboard and print material such as books, teaches students who meet at the same place and at the same time (synchronously). However, as computer technology has become more accessible and cost-effective, there have been various attempts to integrate the microcomputer into educational environments. The invention of the Internet and, more importantly, of the World Wide Web (WWW) has contributed to this new age of electronic education. Millions of pages can now be inter-linked to form a collection of resources that can be both comprehensive but, at the same time, confusing. Sloane's (1997) findings indicated that the web allows students better and more up-to-date information than a traditional university library; affords them more input in their learning process, making education more pro-active; and allows a more individual approach to assessment and learning than is traditionally possible. The implications of such changes are revolutionary, affecting the quality of instruction, its content and its presentation, to name a few. Among the changes is the fact that a student or a group of students may never have to set foot on campus; rather, they can fulfill all the course requirements using the computer and the WWW, never meeting at the same place at the same time (synchronously) to listen to the instructor teaching the courses.

Asynchronous Learning Networks (ALNs), defined as networks for anytime-anywhere learning, combine self-study with substantial, rapid asynchronous interactivity with

¹ Corresponding author Tel: 864 656 5540, e-mail: agramop@ces.clemson.edu

others. In an ALN environment learners use computers and communications technology to work with remote learning resources, including coaches and other learners, without having to be online at the same time. The most common ALN communication tool is the World Wide Web. As the empirical study conducted by Boaz, Carey, Nath, and Ravinder (1997) found, using e-mail, the web and bulletin boards as tools in ALNs achieved the educational goals of completing homework quickly, improving class performance, increasing productivity in class, enhancing learning and increasing the communication with instructor and peers in an environment appreciated by the students. To supplement academic performance and increase the power of ALNs, specialists have experimented with various presentation styles and multimedia components.

Every new technology has its problems, and ALN's are no exceptions. The transition from face-to-face classroom instruction to ALN instruction can be tricky as both Harasim et al. (1995) and Ory et al. (1997) found, especially because students may find the physical non-availability of the instructor and their peers to be a major cause of concern. It is clear that instructional system designers and human factors professionals focusing on training/learning will need guidance on the use of ALNs and, more specifically, on knowing which technology is the best under certain environments to avoid its capricious and arbitrary use. Him et al. (1999) investigated the use of ALNs, developing a methodology to support classroom instruction using alternate delivery systems in addition to investigating various technologies to compliment ALNs. They conducted a study in which the information presented to a class was broken down into modules with the technology being used classified as either low- or high-level. Low- level consisted of digital media including the use of e-mail, graphics, text and audio while high-level incorporated the most current technology available, including not only e-mail, text and audio but also animation, video, synchronization of videos and animation, chat- rooms, and bulletin boards. In addition, their study developed a methodology for the use of ALNs to supplement traditional classroom instruction. In doing so, it did not take into account the various alternatives in delivering instruction (classroom, asynchronous or synchronous). In response to this need, this study evaluated and extended the work done by Him et al. As part of it, an evaluation of low- and high-level technologies to aid in the learning process for a specific course, IE 486: Production Planning and Control, was conducted.

The general objective of this research was to evaluate the use of alternate delivery systems to promote learning as related to the course Production Planning and Control (Bailey and Bedworth, 1987). The specific objectives of this research were: a) To compare the Asynchronous (defined as different place, different time) delivery system with the Synchronous (defined as same place, same time) and the traditional Classroom delivery system (defined as chalkboard and print material) using performance, system process and usability measures, and b) To test the effectiveness of these delivery systems for procedural based tasks.

2. METHODOLOGY

Twenty-four subjects were drawn from undergraduate and graduate classes in the Industrial Engineering Department at Clemson University. All the subjects were in the age group of 18-24 years and were compensated for their participation. Each subject was randomly assigned to one of the following three groups: 1) Asynchronous Group: The asynchronous group received a brief introduction to the task to be performed and instructions in the use of the technology. Instruction was delivered asynchronously; specifically, it was imparted at a different place and at a different time for the different members of the group, 2) Synchronous Group: The synchronous group received a brief introduction to the task to be performed and instructions in the use of the technology. Instruction was delivered synchronously, that is, imparted at the same place and at the same time to all members and 3) Control Group: The control group received instruction in the traditional classroom environment. The content of the learning modules was the same for all the three groups.

2.1 Learning Modules

The learning modules were developed for the Forecasting and Aggregate Planning Modules for a course entitled Production Planning and Control. The Forecasting Module consisted of the Forecasting accuracy measurements which have the following parameters: a) Mean Forecast Error (M); b) Mean Absolute Deviation (MAD); c) Mean Absolute Percent Error (MAP); d) Sample Error Variance (V); e) Auto Correlation at Lag k [AC(k)]. The Aggregate Planning Module consists of comparing two production plans and choosing the one with the higher profit.

2.2 Test Equipment

The equipment needed for the control group receiving instruction in the traditional classroom environment consisted of a chalkboard and material such as class written notes. The test equipment for the asynchronous and synchronous groups consisted of Pentium III computers with 500 MHz CPU clock speed and 128 MB RAM. Real Audio G2 was pre-installed in all of the computers. The modules were accessed from the computers located in the Industrial Engineering Department at Clemson University. These computers were connected using a T1 LAN configuration. All of the computers had Internet Explorer 4.0 or Netscape Communicator 4.0 browsers. As Him (1999) suggested, the technology for the asynchronous and synchronous groups consisted of Real Audio along with text for the Forecasting Module and Microsoft Windows Media player for the Aggregate Planning Module.

2.3 Experimental Design

This study used a two-factor, or Group X Task, design. The group factor, asynchronous, synchronous or traditional type of instruction, was the between subjects factor and the Task was the within subjects factor with 8 subjects tested within each group for a total of twenty-four subjects.

2.4 Procedure

Initially, all the subjects signed a consent form. Then, the subjects were given a brief demographic questionnaire for background testing. Next, each subject was randomly assigned to one of the three groups wherein the subjects received instructions in both Task A (Forecasting) and Task B (Aggregate Planning). The teaching content remained constant in both the learning modules. After this instruction, the subjects were given a quiz over each of the tasks to test their knowledge on the material that they had learned in each module. Each subject filled out a brief usability questionnaire (Him, 1999) for each module and corresponding to the group the subject was in. A common, comprehensive final examination was then given wherein the subjects were asked questions and asked to work problems involving both learning modules.

Data was analyzed for usability questionnaire, performance measures (subject performance on quiz; subject performance on final examination), and process measures (the number of times the module was accessed; and the amount of time each module was accessed)

3. RESULTS

3.1 Performance Measures

Test scores on Quizzes. Mean Scores on Quiz 1 and Quiz 2 were analyzed using a 3 (Groups) x 2 (Task) factorial design. Neither the main effects (Group and Task) nor the interaction was found to be significant. Analysis of Variance conducted on an individual quiz using 3 (Groups) x 1 (Task) design did not show any significant Group effect.

Test scores on the Final Examination. Analysis on final scores using 3 (Groups) x 1 (Task) factorial design did not find the main effect of Group to be significant.

Total Test Scores. The total scores for each student were calculated as the sum of the scores on the quizzes and the final exam score. Again, the analysis using 3 (Groups) x 1 (Task) factorial design did not show any significance for the main effect of Group.

3.2 Process Measures

Time Spent Viewing the Modules. The data was analyzed using a 3 (Groups) x 2 (Tasks) factorial design. The interaction effect of Group x Task was found to be significant ($F(2,21) = 8.10, p < 0.0025$). The main effect of Group ($F(2,21) = 3.59, p < 0.0455$) and Task was found to be significant ($F(2,21) = 54.62, p < 0.0001$). Fisher's Least Significance Difference (LSD) Test separating the six interaction means showed that the amount of time spent was not significantly different for the Synchronous and Asynchronous Groups for the Forecasting Module and for the Classroom and Asynchronous Groups for the Aggregate Planning Module.

Number of Times the Modules were Accessed. The data was analyzed using a 3 (Groups) x 2 (Tasks) factorial design. The interaction effect of Group x Task ($F(2,21) = 21.00, p < 0.0001$) was found to be significant as were the main effect of Group ($F(2,21) = 22.40, p < 0.0001$) and Task ($F(2,21) = 21.00, p < 0.0002$). The Fisher's Least Significance Difference (LSD) Test showed that no significant difference between the Classroom and Synchronous Groups for each module. Also, these Groups did not show any difference across both the modules by themselves.

3.3 Usability Measures

Cronbach's Analysis. Subjects in all three Groups responded to 10 questions on the Usability Questionnaire concerning the usability of the system. The responses were recorded using a five-point Likert scale, with one being very strongly disagree and five being very strongly agree. The questions were organized into the following four categories: 1) Content, 2) Usefulness, 3) Organization, and 4) Learning.

A Cronbach's Coefficient Alpha (Cronbach, 1951), for the questions along with their mean score and standard deviation for each Group, was calculated to ensure that it was appropriate to place them into a particular category. The Alpha Coefficient can be expressed mathematically as

$$\text{Alpha} = \left[\frac{k}{k-1} \right] \left[1 - \frac{\sum Vi}{Vt} \right]$$

where

k = the number of questions combined,

Vt = the variance of the participants, total scores, and

Vi = the sum of the variances of the responses for each individual question.

To ensure that the questions would yield interpretable results about usability, the Cronbach's Coefficient Alpha should be greater than 0.5 and less than or equal to 1.0 (Cronbach, 1951). The alpha coefficients were calculated separately for the three different groups. Since the coefficients for all the groups were within the prescribed limits it was found appropriate to group the questions into their respective categories. For each usability category, the data was analyzed using a 3 (Groups) x 1 (Category) factorial design and separate ANOVA's were conducted.

Content. The main effect of Group was not found to be significant. However, the main effect of Task ($F(1, 21) = 9.33, p < 0.006$) was reported to be significant. The mean score of responses in the "Content" category was higher for the Forecasting Module than the Aggregate Planning Module.

Usefulness. The main effect of both Group ($F(2, 21) = 8.64, p < 0.0018$) and Task ($F(1, 21) = 24.95, p < 0.0001$) was found to be significant. Fisher's LSD Test for the mean responses in the "Usefulness" category for the different Groups showed that the

responses between the Classroom and Synchronous Groups and the Synchronous and Asynchronous Groups were not significantly different.

Organization. It was found that the main effect of Group was not significant. However, the main effect of Task ($F(1,21)=14.78$, $p < 0.009$) was significant. The mean score of responses in the "Organization" category was higher for the Forecasting Module than the Aggregate Planning module.

Learning. The main effect of both Group ($F(2,21)=3.68$, $p < 0.042$) and Task ($F(1,21)=8.04$, $p < 0.0099$) was found to be significant. Fisher's LSD Test for the mean responses in the "Learning" category for both the Classroom and Asynchronous Group did not result in any significant difference.

4. DISCUSSION AND CONCLUSIONS

Analysis of data for the performance measures, which included two quizzes, a final exam and the total score, did not reveal any significant differences across Groups, Task or the interaction between Groups and Tasks. The most salient finding with respect to this measure was that performance was not sensitive to the type of delivery system. The finding in this research, thus bodes well for the concept of Asynchronous Learning Networks (ALNs) using computers in this study since the subjects performed as well as, if not better than, the subjects in a well-designed traditional Classroom delivery system.

Analyzing the data for the former, we note that there is a significant interaction effect between Groups and Tasks indicating that depending on the group and the task involved, subjects spent variable amounts of time on learning. In addition, the mean time spent on the Aggregate Planning Module was higher in each group than that for the Forecasting Module.

The increased amount of time in the Aggregate Planning Module might indicate a more complex task than the Forecasting Module, one with more involved procedural tasks. Also, many of the concepts needed for the Forecasting Module concepts might have been covered in the other related courses, the impact of prior knowledge that carries over for a current task. This carry-over effect was certainly not the case with the Aggregate Planning Module.

The data concerning the number of times the subjects viewed the modules indicated a similar interaction existed between Groups and Tasks. The number of times the module was accessed by the Asynchronous Group was more for the Aggregate Planning Module than the Forecasting Module. The Classroom and Synchronous Groups viewed each module only once.

REFERENCES

- Bailey, J. E. and Bedworth, D. D., 1987, *Integrated Production Control Systems*, John Wiley & Sons, Inc.
- Boaz, Carey, Nath and Ravinder, 1997, *Asynchronous learning environments: An empirical study*. Proceeding of the 1997 Annual Meeting of the Decision Sciences Institute, v2, Part 2 of 3, 22-25, San Diego, CA.
- Harasim, L., Hiltz, S., Teles and L., Turoff, M., 1995, *Learning networks: A field guide to teaching and learning online*. Cambridge, MA: MIT Press.
- Him, H., Nickels, G., Leonard, M., Kimbler, D. and Gramopadhye, A. K., 1999, *Teaching Industrial Engineering Coursework using Instructional Modules and Competency-based Testing*. Proceedings of the 1999 Industrial Engineering Research Conference, Phoenix, AZ.
- Ory, John C., Bullock and Cherly, 1997, *Student use and attitudes about On-Campus ALN*. Proceedings of the 1997 27th Annual Conference on Frontiers in Education. June 28 – July, 1(1), 416-429.
- Sloane, A, 1997, *Learning with the Web: Experience of using the World Wide Web in a Learning Environment*, *Computer Educ.* 28(4), 207-212.