

AC 2007-1031: LEARNING EFFECTIVENESS AS A FUNCTION OF THE TECHNOLOGIES EMPLOYED IN ONLINE LEARNING SETTINGS

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Learning Effectiveness as a Function of the Technologies Employed in Online Learning Settings

Abstract

Technology is often viewed as an important factor that impacts the effectiveness of online learning systems. To explore the importance of various technologies, the authors conducted a comprehensive study that investigates the experiences of students and instructors that are involved in online learning. A number of questionnaires concerning perceptions, experiences, resources, and perceived effectiveness related to online education developed by the research team have been administered to a sample of students (over 4,500) at a large number of educational institutions throughout the United States. Survey participants constitute a large sample group that represents diverse backgrounds from geographically dispersed institutions worldwide. Responses were analyzed and discussed in the paper. The analysis focuses on the utilization of technology in online education and explores how students view its effectiveness as a function of the types of technologies used. Study covers various standard technologies such as instant messaging, email, discussion boards, chat rooms, web conference, audio communication, and electronic whiteboard as well as the use of relatively new virtual reality based environments. A comparative analysis was also conducted to identify the differences between face-to-face and online learning settings. Based on the findings of the analysis and the data gathered from the survey participants, a number of design methods and techniques that would influence the development of effective online course delivery systems are developed. This study is the first step in a longer program of research that will ultimately yield enhanced systems for online learning.

1. Introduction

Effectiveness of online learning settings has become an important research question as the number of online programs increase dramatically in the last decade. Numerous researchers studied the effectiveness of online education. Since the research problem has multiple dimensions, different researchers focused on different aspects of online learning. For example, some researchers have studied the effectiveness of online learning by focusing on its implications on performance in work place. Lima et al. studied the determinants of effective online training to reveal how these variables affect learning performance and transfer performance, two important elements of training effectiveness in the workplace. Their study shows that effective online education (OE) systems need ease of interaction, computer self-efficacy, and efficient communication in the virtual perspective as well as institutional factors such as support of seniors and continuous learning culture¹.

The question of how to assess the effectiveness of online education is a challenging one by itself. Rovai² proposed a framework that is designed to assess student performance, determine program and cost effectiveness, monitor quality of technology and support

services, and evaluate course design and instruction. Rovai's approach is based on administrator's perspective on the performance evaluations of online programs.

To illustrate another different research perspective, Shea et al.³ focus on two components of a model for online teaching and learning—"teaching presence" and "community". According to their research, teaching presence is viewed as the core role of the online instructor and it is a promising mechanism for developing learning communities in online environments. Their investigation presents a multi-institutional study of 1067 students across 32 different colleges. Shea indicates that "there is a clear connection between perceived teaching presence and students' sense of learning community. This study reveals that a strong and active presence on the part of the instructor—one in which she or he actively guides and orchestrates the discourse—is related both to students' sense of connectedness and learning".

Another research stream focuses on students' behavioral characteristics to predict their success in online classes. As an example of behavioral studies, Kerr et al.⁴ used a specific tool that is called TOOLS (Test of Online Learning Success) to measure students' ability to perform different tasks. TOOLS can identify students' individual behavioral strengths and weaknesses regarding online learning. Researchers believe that the outcomes of their study can be used to design and deliver online courses that meet student needs and abilities better.

The objective of this paper is to study the technological aspects of online learning systems. Technology is often viewed as an important factor that impacts the effectiveness of online learning systems. To explore the different aspects of the effectiveness of online education, the authors have conducted a comprehensive study that investigated the experiences of students that are involved in online learning. A number of questionnaires concerning perceptions, experiences, resources, and perceived effectiveness related to online education have been developed by the research team and they have been administered to a sample of students at a large number of educational institutions throughout the United States. Survey questionnaires have been employed both in online and paper formats. Survey data were gathered from 4792 students from 125 institutions. Survey participants constitute a large sample group that represents diverse backgrounds from geographically dispersed institutions throughout the United States.

This paper discusses and analyzes the utilization of technology in online education and explores how students view its effectiveness. Therefore, this paper is focused on analyzing the effectiveness of OE settings as perceived by students. Study covers various standard technologies used in online learning such as instant messaging, email, discussion boards, chat rooms, web conference, audio communication, and electronic whiteboard as well as the use of relatively new virtual reality based environments.

2. Online Course Delivery Systems

In order to understand the structure of this study, it is useful to discuss the basics of online learning systems. Online education systems feature special tools that facilitate the

delivery of courses. An online learning system has to provide tools for creation and management of an effective user interface together with all of the components required for an educational program. The main components of online learning environments are as follows:

- Administrative information
- Announcements
- A file management system that stores the teaching material
- Online testing tools
- Database systems to record students' performance
- Electronic communication and collaboration tools:
 - e-mail,
 - discussion boards
 - chat rooms
 - instant messaging
 - electronic whiteboard
 - voice and/or video enabled chat

A successful online learning system should integrate all the elements listed above together.

Table 1. Analysis of survey participants (gender)

	Frequency	Percentage
Female	1682	64.66
Male	3078	35.34

Table 2. Educational backgrounds of survey participants

Student Groups	Frequency
Freshman	660
Sophomore	756
Junior	942
Senior	1076
Masters Student	822
Doctoral Student	250
Non-degree Student	96
Other	190

3. Analysis of the Survey Participants

Survey results have been gathered from a large diverse sample group. 64.66% of the participants were female as shown in Table 1. Both graduate and undergraduate students have participated in the survey. 71.6% of the students were undergraduates while graduate students constituted 22.4% of the sample group and 51% of the group had no online education experience. Seniors, juniors, and masters students were the three largest

student groups that participated in this study. Table 2 shows the analysis of students' educational background.

Survey participants have different levels of online education experience (see Table 3). Almost half of them have not taken any online classes. Students who had substantial amount of online learning (those who have taken more than 6 online courses) experience constituted 10% of the sample.

Table 3. Students' experience in online education

Online Course Experience	Frequency	Percentage
Haven't taken any online course	2438	51.27
Have taken 1 - 3 online courses	1400	29.44
Have taken 4 - 6 online courses	427	8.98
Have taken more than 6 online courses	490	10.3

3. Technological Elements in Online Courses

The survey addresses various technological elements that play important role in the effectiveness of the online learning systems. The first area of interest involves the type of Internet connection used by the students in classes. Speed of Internet connection is an important issue, since the type of communication used in classes is related with the bandwidth capacity. For example, video and audio based presentations are often infeasible with dial-up connections. Broadband connections provide communication capacities that allow the use of media-rich course material. According to the survey results, only 4.6 % of the students indicated that they use dial-up connection to observe the online courses. 74.2 % of them specified their connection type as broadband. Wireless connection is used by 11% of the survey participants. Furthermore, survey results indicated that some students were not familiar with the terms that define the Internet connection type, therefore, omitted answering this question.

Our survey results revealed that Blackboard is the most prominent platform among online learning systems with an adoption rate of 62%. WebCT is the second and used by 26% of the participants. Majority of the students were satisfied by the quality of the course delivery system that they use. By using a scale of 1 to 5, they rated the overall quality of online learning systems to be high (M=4.0, SD= 0.96). In another question, using the same scale (1 to 5) most students gave high scores for the reliability of the systems that they use (mean value for reliability scores was 4.14 while SD was 0.85).

A number of survey questions focus on the use of different technologies in online classes. Authors have identified 21 key technological components that are available in today's Internet based learning tools. In order to understand how frequently those technologies are employed in classes, students were asked to rate (1 to 5 scale) each key technology according to its frequency of utilization. Table 4 shows the rating scheme and the summary of the responses. According to the results shown in Table 4, email is the most widely used communication tool in online settings. The importance of email

communication in online courses has been articulated by other researchers such as Lightfoot⁵. Lightfoot's research indicated that students put significantly more thought into e-mail communication with the instructor and groups of peers than they do for equivalent face-to-face (FTF) communication.

Table 4. Frequency of utilization of different technologies in online classes

Tool	Frequency of Utilization	
	M	SD
Email communication with instructor	4.25	1.04
Online digital drop box (for submission of projects, homework, assignments)	3.72	1.47
Online asynchronous discussion board	3.35	1.55
Slide presentations (e.g. PowerPoint)	2.96	1.58
Course-specific web page	2.93	1.60
Online testing that is not proctored	2.80	1.66
Archived online lecture/meeting (asynchronous)	2.60	1.61
Online synchronous chat room	2.10	1.37
Telephone communication with instructor	2.07	1.36
Proctored online testing	2.04	1.47
Student presentations in asynchronous format	2.01	1.40
Scheduled online lecture/meeting (synchronous)	1.95	1.31
Lecture with video <u>and</u> audio input from the teacher	1.80	1.27
Electronic white board	1.76	1.26
Remotely accessible lab/virtual lab	1.70	1.18
Lecture with audio <u>but no</u> video input from the teacher	1.58	1.06
Instant messaging	1.55	1.05
Student presentations in synchronous format	1.53	1.04
Student participation with live video <u>and</u> audio	1.39	0.89
Student participation with live audio <u>but no</u> video	1.36	0.86
3-D virtual classroom resembling face-to-face classroom environment	1.28	0.81

1=Not At All 2=Rarely 3=Sometimes 4=Often 5=Almost All the Time

Students rated online digital drop boxes as the second most widely used technologies in online courses while discussion board is the third most popular tool with a mean score of 3.35. Use of synchronous communication such as telephone, chat-rooms, and instant messaging is less common than asynchronous mode technologies. It is interesting to note

that the use of live video and audio is not as common as synchronous mode tools although the available technologies have matured in that area.

Table 5. The use of tools according to perceived effectiveness of learning

Technologies/Tools	A Results obtained from students who describe learning effectiveness of OE courses less favorably than FTF (Percentage of courses that use the identified technologies)	B Results obtained from students who describe learning effectiveness of OE classes better or as good as FTF classes (Percentage of courses that use the identified technologies)
Lecture with video <u>and</u> audio input from the teacher	32.5	36.0
Lecture with audio <u>but no</u> video input from the teacher	25.5	29.2
Scheduled online lecture/meeting (synchronous)	40.3	42.1
Archived online lecture/meeting (asynchronous)	57.5	58.7
Student participation with live video <u>and</u> audio	17.8	20.2
Student participation with live audio <u>but no</u> video	17.5	19.0
Slide presentations (e.g. PowerPoint)	67.5	70.2
Electronic white board	32.7	33.6
Online synchronous chat room	46.3	48.5
Online asynchronous discussion board	76.3	78.9
Online digital drop box (for submission of projects, homework, assignments)	82.9	84.2
Email communication with instructor	97.3	97.8
Telephone communication with instructor	44.4	48.5
Instant messaging	23.1	27.1
Remotely accessible lab/virtual lab	32.6	33.3
Proctored online testing	38.7	39.4
Student presentations in synchronous format	24.1	26.0
Student presentations in asynchronous format	35.8	41.3
Online testing that is not proctored	60.5	61.9
Course-specific web page	65.5	68.4
3-D virtual classroom resembling face-to-face classroom environment	12.6	13.8

Table 5 analyzes the impact of different technologies and tools employed in OE settings on perceived learning effectiveness. Column A represents the rate of technology used in courses that are taken by the students who rated OE learning as less favorable than face-to-face classes. Column B provides the same information for the courses taken by the students who rated OE learning effectiveness as satisfactory. Results indicate that students think they learn better when the overall utilization of distance education tools and technologies are more frequent. Table 5 also shows that the certain technologies have higher impact on the students' perception of learning effectiveness more than others. Following features were found to be significant in determining the learning effectiveness in OE settings: instant messaging, lecture with video and audio, lecturing with audio, telephone communication with the instructor, and student presentations in asynchronous

mode. Some of those elements (telephone communication and instant messaging) signal the importance of direct and real-time communication between instructors and students.

4. Virtual Reality Based Online Learning Environments

One relatively new concept in online education is the use of virtual reality technology. Virtual reality technology enables students and instructors to share a common 3D space that resembles a real physical environment. Virtual reality platforms offer new capabilities that have a great potential to aid students' learning. There are a number of innovative e-learning applications that use 3-D virtual reality based communication and collaboration tools. Virtual-reality technologies have been used in flight simulation to train pilots and assess their competency for decades. Other educational applications emerge everyday. There are successful examples in the area of medical training. For example, Brenton et al.⁶ reported the use of virtual reality in anatomy classes. Their system allows instructors to modify 3D models over the Internet while explaining the subject matter to the audience at the same time. In a similar work, Khalifa et al.⁷ studied the use of virtual technology in ophthalmology training.

Most virtual reality systems are not designed solely for the purposes of education. Therefore, they usually lack the education-specific tools that other standard Internet based course delivery systems have. Recently, Second Life, a virtual reality system has gained popularity and has been adopted by a number of institutions. The online learning applications that are hosted on Second Life platform has been covered by popular media⁸, which reported Rebecca Nesson's application on Second Life. Nesson teaches a class jointly offered by Harvard Law School and Harvard Extension School in the world of "Second Life." Nesson indicated that "students interact with each other and there's a regular sense of classroom interaction. It feels like a college campus."⁸

Second Life is a subscription-based 3D Virtual world. The Second Life client program provides its users tools to view and modify the virtual world and participate in its economy. The majority of the content in the Second Life world is created by its users. In this virtual world, users can create objects, buildings, and customize their environments. Therefore, it is possible to build a classroom within Second Life. Users are represented by their avatars, which may be customized in a variety of ways. The basic avatar is humanoid but its shape is modifiable. For example, size, build, color, and hair style of avatars can be changed. Users can also create or buy clothing, and attach 3D objects to their avatars to further customize them. The system also allows users to use non-humanoid character representation if they choose to do so.

All objects and 3D information are streamed in real-time to all clients. System works in real time; therefore, any modification that is done by a user is broadcasted to all users. Using SL's 3D modeling and programming language, one can build virtual laboratories.

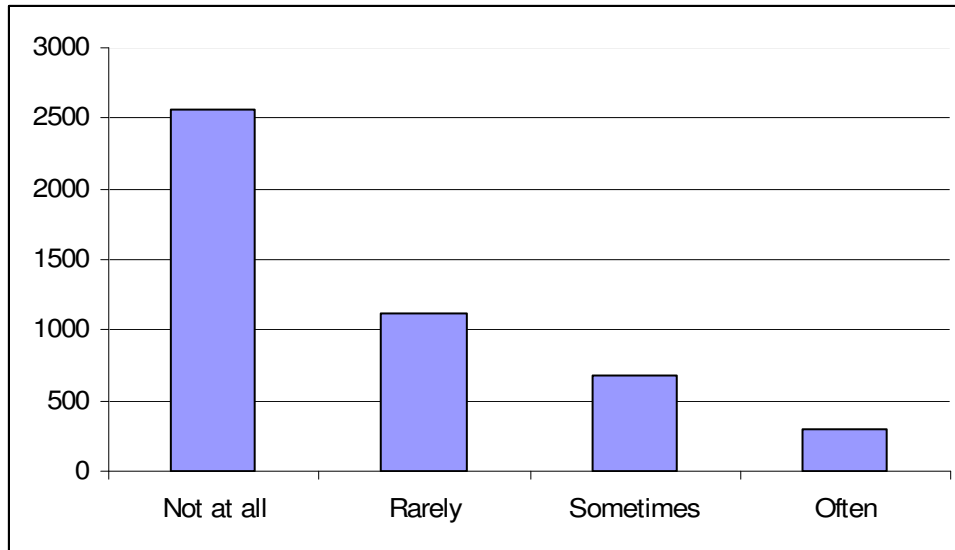


Figure 1. Students' experience with virtual reality based games. (*Analysis of the responses to the following question: Survey Question: How often do you play online 3D games?*)

The use of virtual reality may be most effective when users are familiar with the utilization of synthetic 3D environments. Some users find it difficult to navigate in virtual reality based environments. Most modern computer games are created on a virtual reality platform. Therefore, those who have computer gaming experience may adapt virtual reality based instruction more effectively. The survey investigated students' experience with video games in order to predict the adoption rate for this relatively new technology. According to the survey results, 45% of the students are familiar with 3D computer games although their game play frequency varies. Figure 1 summarizes students' experience with 3D computer gaming. One of the survey questions asked students about their experience with virtual reality based online education systems. 15% of the participants indicated that they have experienced such systems.

Table 5. Students' Experience with 3D/Virtual Reality based learning systems.

(*Analysis of the responses to the following survey question: have you ever experienced any educational 3-D/virtual reality based instruction?*)

Response	Frequency	Percentage
Yes	707	15.26
No	3925	84.74

Some of the survey questions focused on students' overall assessment for the Internet-based instruction. When students are asked which type of course delivery mode they

prefer, 45% of them indicated they prefer face-to-face classes. 37% of the students opted for online courses while 17% had no preference for one to another.

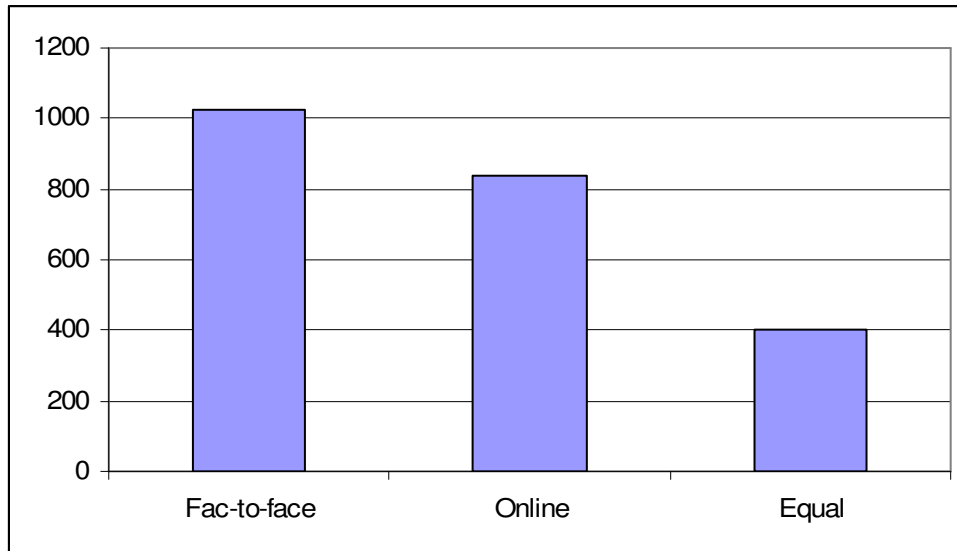


Figure 2. Student preference for taking online classes.
(Analysis of the responses for the following survey question:
“If you had a choice, which one would you prefer?”)

5. Conclusions

Authors have gathered valuable data from a large group of students. The survey results have helped us understand the technological elements that are involved in online settings. Results indicate that most online classes use asynchronous communication modes more often than synchronous mode. Email communication has been identified as the most frequently used tool in online classes. The analysis of the survey responses shows that the majority of online classes rely on the use of text-based communication tools. The use of more advanced and media-rich Internet-based communication technologies (e.g. virtual reality, video conferencing) is limited although adequate bandwidth is available in many cases. As a next step, authors will investigate how each technological element is related to the students’ perception of effectiveness of online education.

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