A Field Experiment in Blended Learning

Performance Effects of Supplementing the Traditional Classroom Experience with a Web-based Virtual Learning Environment

Completed Research Paper

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ABSTRACT
This study examines the efficacy of blended learning—an approach that seeks to combine traditional and online methods in a way that leverages the strengths of both—using a field experiment spanning nearly four months. An information-processing model of learning suggests that information accessibility plays a key role in learners’ interaction with the available information source and can thereby affect learning outcomes. Results of our study suggest that information accessibility does, indeed, impact the efficacy of blended learning by providing high value content in low cost settings, thereby enhancing performance. The largest gains in performance were seen by those who used the blended learning system the most, with the lowest gains by those who did not use the system at all (i.e., the control group).

Keywords
Blended learning, e-learning, virtual learning environments, Web-based education

INTRODUCTION
Much e-learning work (e.g., Alavi, Marakas and Yoo, 2002; Arbaugh and Benbunan-Fich, 2006; Santhanam, Sasidharan and Webster, 2008) has focused on supporting anytime/anyplace learning as an alternative to traditional classroom learning. Such efforts have precipitated a spirited debate regarding which learning styles (Proserpio and Gioia, 2007), environments (Daspit and D’Souza, 2012), and mode-of-delivery (Armstrong and Sadler-Smith, 2008) provide the best outcomes. Recently however, has come the reminder that “processes do not have to be purely physical or purely virtual” (Overby, Slaughter and Konynski, 2010: 702), leading to the development of “blended” scenarios that strive to strike an optimal combination of traditional and e-learning elements, leveraging the strengths of each. In this paper, we report on a field experiment designed to test a specific instance of the blended learning concept in a controlled, yet realistic setting, where the results provide support of the concept and offer guidance for academia and industry.

BACKGROUND
Overby, Slaughter and Konynski (2010) make a strong case for research on the virtualization of processes, including both business and educational processes, stating the need to understand how virtual processes should be designed and when people should use virtual processes to supplement or substitute for physical processes. Consistent with this view, Alavi and Leidner (2001) provide a model that differentiates information technology and instructional strategies from the psychological learning processes with the goal of identifying precisely how human cognition and artifacts interact in an educational setting. They argue that technology-mediated learning (TML) should not attempt to replicate traditional learning and thus the research should shift away from comparing the two approaches toward “forming relationships among technology and relevant instructional, psychological and environmental factors that will enhance learning outcomes.” This shift is realized, we believe, with the blended learning approach.

Blended learning is traditionally described as a learning approach combining the use of instructional technologies with classroom learning (Wu, Tennyson and Hsia, 2010). Definitions range from the simple inclusion of a Web site to supplement classroom teaching (Arbaugh, 2008) to more specifically defined combinations describing the percentage of content delivered, or time spent, using each delivery method (Allen, Seaman and Garrett, 2007). Marsh (2001) defines blended learning as “taking the best from self-paced, instructor-led, distance and classroom delivery to achieve flexible, cost-effective training that can reach the widest audience geographically and in terms of learning styles and levels.” Along similar lines, Zenger and Uhlein (2001) acknowledge that traditional and e-learning approaches, while fundamentally different, have
complementary strengths. For instance, the traditional learning approach provides a rich social context—one with “real” instructors and “live” students—in which to learn. This context enables immediate feedback, facilitates clarification and encourages interaction—all of which are essential for learning to occur. In comparison to traditional learning, e-learning offers other advantages such as enabling learning to occur at the student’s pace and place (rather than those of the institution, instructor or other students) (Santhanam et al., 2008). The emphasis on efficiency means that significant cost savings can result from people not needing to travel to learn, stay away from work or family, and reschedule their lives around classes. Also, since students progress at their own pace, they will not hold back others or become bored by a slower pace. Thus, learners can repeat parts of a program that are not clear to them.

RESEARCH FRAMEWORK AND HYPOTHESES

Theory, Research and the Model
Piccoli et al. (2001) describe Virtual Learning Environments (VLEs) as computer-based environments that rely on a collection of tools—including multimedia, simulation, animation and communication—to free learners from the constraints of time and place, facilitate collaboration among learners and provide high levels of learner control over pacing and sequence. With the Web 2.0 platform, examples of such VLEs proliferate, including widely used products such as WebCT and Blackboard.

The VLE model identifies two antecedents—the human and design dimensions—to the learning process. The human dimension comprises instructor characteristics, such as teaching style, attitude toward technology, and availability, and student characteristics, such as maturity, motivation, and comfort with technology. In addition, the design dimension, focusing on the features of the VLE, consists of factors such as technology quality, system availability, and frequency of interaction. This design dimension corresponds well to the information technology component from Alavi and Leidner (2001) while additionally accounting for individual needs. Given these links, the two models are easily merged by viewing the learning process as a mediator between the two antecedents and the learning outcomes (See Figure 1).

Figure 1: Theoretical Framework

This model is consistent with Gagné’s (1985; 1975) general theory of instruction that views learners as decision makers and is line with more recent work (Jarvenpaa and Leidner, 1995; Sasidharan and Santhanam, 2006) on technology-mediated learning that characterizes learners as active, even somewhat autonomous, participants in their own learning. In such a paradigm, learners provided with an array of information resources “optimize” their learning by distributing their limited time and effort wisely among the alternatives. Given this “pull” rather than “push” perspective, learners come into view as decision makers, evaluating information sources for quality, relevancy and accessibility. Within this learner-centric context, Carlson and Davis (1998) identify information accessibility as the key element in explaining system use. This result is not
particularly surprising in light of Mooers’ Law (1959, p.1), which states that “an information retrieval system will tend not to be used whenever it is more painful and troublesome for a customer to have information than for him not to have it.” Regardless of the efficacy of the underlying theoretical explanation, it is clear that accessibility is a cost function and one that affects source choice by a learner.

Based on the above theoretical discussion, in our context, the learner—operating under uncertainty within time/effort constraints—can be viewed as a decision maker seeking to optimize performance given multiple information alternatives. In the effort to maximize efficiency, the relative “cost” of accessing information will affect the learner’s propensity to work with the various alternative content sources such as books, lecture notes, or online resources, assuming acceptable quality standards across the spectrum of choices.

Reducing the relative accessibility cost of high value content sources then, can be expected to increase learners’ “time on task” with those sources, and thereby lead to better outcomes. A Web-based VLE then might be expected to result in positive outcomes merely by exploiting the fundamental nature of Web 2.0 elements aimed at enhanced accessibility. To summarize, our research framework depicted in Figure 2—which merges concepts from Leidner and Alavi (2001) and Gagné (1985) with the model articulated by Piccoli et al. (2001)—proposes that information accessibility, with other factors being controlled, serves as an antecedent of the blended learning process that includes interactions with the instructor and VLE, which in turn serves as the antecedent to learning effectiveness. In addition, our model also adds an important dimension that has been an integral part of previous research on learning (e.g., Gagné, 1975; 1985), but has largely been absent from research on VLEs—the feedback loop. The inclusion of this loop, via the double-headed arrow, suggests that prior outcomes will influence a learner’s future interactions with the instructor and VLE.

![Figure 2: Research Model](image)

**Research Hypotheses**

Ostensibly, one of the strengths of traditional classroom learning is the value added by the face-to-face interaction with the instructor and classmates. Often the instructor adds a layer of content on top of the textbook or other written material, using the richness of verbal communication to enliven the material, enhance understanding and motivate students. For example, Gagné (1985) discusses advance organizers that improve learning and retention of information by “reminding the learner of the meaningful context already available in memory and relevant to the new learning” and “informing the learner of the objective” either directly or by adjunct questions. And, in addressing the presentation of stimulus as one of the events of instruction that support learning processes, he highlights the value of the audio component, stating “when speech is delivered orally, the lecturer gives emphasis to distinctive features by variations in pitch and tone.” (p. 252) Thus, the classroom session can be viewed as a high value information source among the blended learning components.

At the same time, classrooms are highly constrained channels in terms of time and place, and maximize the risk of “missing” the communication entirely. The messages are transient in nature and thus must be absorbed in real time and/or captured in a persistent form as notes, typically recorded during the transmission, that can be reviewed later but which represent a generally low-fidelity, second generation “copy” of the original message that by its very nature must fail to capture some
content buried in the rich verbal medium. Indeed, referring to students in a lecture, Gagné (1975) states, “Most may be taking notes, which, so far as anyone knows, is an entirely useless activity quite unrelated to learning.” (p. 287)

However, as has been widely acknowledged, Web based-systems are capable of providing “anytime/anywhere” access, greatly mitigating the constraints of time and place. Based on the type of system, however, the enhancement of information accessibility may differ in nature and degree. Culnan (1984) articulated multi-dimensional access with physical, retrieval and usability aspects that, though predating the Web, carry over well. Similarly, in the emerging mobile-learning environment, handheld devices can be viewed as the minimal requirement for “anywhere” access. Retrieval and usability continue to be a challenge as the volume and nature of information continues to evolve and grow dramatically. Research on intelligent relevancy-based search mechanisms, indexing, and other technologies represent efforts to address accessibility issues (Adipat, Zhang, and Zhou, 2011). In exploring their effects then, it is important to identify the nature as well as degree of information accessibility.

Based on the above discussion, we deduce the following two hypotheses:

\[ H1: \text{Performance improvements will result from learners using VLEs in addition to traditional classroom instruction.} \]

\[ H2: \text{The performance of learners using VLEs and classroom instruction will improve more than the performance of those with only classroom instruction.} \]

The first hypothesis seeks to isolate gains (if any) from VLE use in a blended learning context, and thus can be tested in a controlled setting such as the one in this study by examining different types of treatments. The second hypothesis is broader in scope in that it seeks to compare the effects of VLE use in less controlled settings, such as when VLE use may be voluntary—a treatment examined in this study as well.

A secondary goal of this study was to examine the relevance of the feedback loop in a blended learning context. The widely cited technology acceptance model suggests that users’ perceptions of usefulness and ease of use will influence technology use. Empirical studies of VLEs (e.g., Alavi et al., 2002; Piccoli et al., 2001) have provided mixed support for this view. Research on learning suggests a variety of factors, including psychological learning processes (Gagné, 1985), technological considerations (Alavi et al., 2002), training methods (Gupta and Bostrom, 2009) and learner control (Piccoli et al., 2001) that are likely to affect the type and extent to which learning resources are used by learners. In the context of blended learning—consistent with our research model—learners, in an effort to maximize learning efficiency, will be influenced by prior outcomes in the extent to which they interact with VLEs. In particular, where they have not performed well, they are likely to seek out and use available resources, provided the cost to use such resources is not high. Thus, we deduce the following hypothesis:

\[ H3: \text{The extent to which learners interact with a VLE will be inversely related to their prior performance.} \]

EXPERIMENTAL DESIGN AND METHODOLOGY

To test the hypotheses articulated above we exploited the nature of blended learning environments as collections of content elements with varying degrees of accessibility. Three sections, totaling 138 students, of an undergraduate networking course for MIS majors at a large university in the western United States provided for the experimental context. Each of the three sections was randomly assigned to one of three treatments—required use, optional use or no use of the VLE. In the required use treatment, students were informed that their use was being recorded and a minimum of three hours of use per student was mandatory. In the optional treatment, students were informed of the availability of the system and its capabilities and invited to use it at their own discretion. In the control group, the existence of the system was never announced and no user logins were provided.

Specifically, the blended learning approach was implemented by offering traditional classroom sessions in conjunction with a collateral VLE, using WebCT, which included many of the typical components described by Piccoli et al. (2001), such as integrated e-mail and online discussion. An integral part of the VLE was the session replay capability, which replicated the audio-visual experience of being in a classroom environment. During each classroom session, the lecture was audio taped and later edited and synchronized to the PowerPoint slides used during the class lecture. Audio recording was selected rather than video to ensure the greatest level of accessibility and to ensure visual focus on the slide material. Additionally, using the VLE, students could easily access course materials, a course calendar, and could interact online with each other and with the instructor. However, given the rather technical nature of the material, a classroom session component was an integral element of the course and thus a blended, rather than distance-learning approach was adopted. The VLE system provided Web-based, streaming audio, classroom session replays as part of a blended learning course. Using the replay system, students could view or review actual classroom sessions, including audio-enabled slides, on their own time via any Web browser.
The dependent variable of interest in hypotheses H1 and H2 was performance, and was measured using exam scores. The playback system was introduced after the mid-term exam, the grades from which served as pre-test scores. Thus, the midterm score served as a covariate in the analyses to control for differences in pre-existing subject knowledge. The final exam scores served as the post-test scores. In testing hypothesis H3, the dependent variable of interest was the extent of a learner’s interactions with the VLE and was operationalized as the number of times a learner accessed the audio-enhanced slides on the site (through sequential navigations, hyper-linked clicks, or key word searches).

**DATA ANALYSIS AND RESULTS**

Pre-session questionnaires were used to collect demographic data and subjects’ perceptions of the process and technology. The subjects, on average, were about 25½ years of age, with 58% being females. Attendance data was monitored for all sections; however, no significant differences in attendance were evident across the three treatments.

Three sets of analyses were conducted after the data distributions were checked for normality. First, an ANCOVA was performed to examine whether test scores differed across the three treatment conditions. Table 1 summarizes the results of this analysis.

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<th>F</th>
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This analysis provided strong support for hypothesis H1. Note that the scores on the mid-term exam—prior to the application of the treatment—were significantly different across the three groups ($F_{1,137} = 63.48, \ p < .001$) with the control group scoring significantly higher than either the required use or the optional use groups. However, after the treatment was applied, and the students took their final exam, the differences in scores while still present, ceased to be significant ($F_{1,137} = .780, \ p = .460$). In other words, the analysis indicates that the significant initial differences in performance across the groups dissipated after the system was made available and used by the treatment groups. In fact, inspection of the means confirms that the results were in the expected direction. (The largest average gains in performance were seen by the required use groups (4.5) and the smallest by the control groups (.7), with the optional use groups falling in between (.9)).

The second set of analysis involved the conduct of another ANCOVA, focused this time on comparing the differences in performance between those who actually used the system and those who did not. In other words, “users” included the entire required use treatment group along with those students in the optional use group who did, in fact, use the system (about half). Conversely, “non-users” included the entire control group along with those students in the optional use group that chose not to use the system (the other half). Here again, the mid-term scores were treated as the covariate and the final exam scores served as the dependent variable. Table 2 summarizes the results of this analysis.
As in the earlier instance, the analysis provides strong support for hypothesis H2. Note that the scores on the mid-term exam—prior to the application of the treatment—were significantly different across users and non-users ($F_{1,137} = 69.85, p <.001$) with the non-users scoring significantly higher than the users. However, after the treatment was applied, and the students took their final exam, the differences in scores while still evident, ceased to be significant ($F_{1,137} = .780, P=.460$). Thus, users of the system were able to improve their performance relative to that of the non-users. In fact, the non-users’ performance scores were almost identical before and after the treatment, while the users’ scores improved significantly after the treatment. This analysis, in conjunction with the previous one, offers compelling empirical evidence to support our expectations that using the VLE can help improve learners’ performance.

The last set of analyses involved the examination of the factors that affected the extent to which the system was used. The dependent variable was the extent of system use and was measured as the number of times a student listened to an audio clip or reviewed a slide. Since every single mouse click was recorded, system usage was measured objectively and precisely. A stepwise regression was conducted to test which, if any, of the factors—including control variables such as demographics (age and gender), perceptions (usefulness and ease of use) or prior performance (mid-term exam scores)—affected system use.

The adjusted R-squared was .164 ($F_{1,137}=5.12, p=0.035$) and the only independent variable that affected usage was prior performance. As expected in hypothesis H3, there was a significant negative relationship between VLE use and midterm exam scores ($\beta=-.451, t=-2.26, p=0.035$). Thus, those students who did poorly in the mid-term exam were looking for efficient ways to improve their performance and found it in the form of the VLE. Thus, hypothesis H3 was supported.

**DISCUSSION**

Our results suggest that lowering the cost of accessing a high value learning component, by providing a Web-enabled classroom session replay system, had a significantly positive impact in improving the performance of those who used it. The benefits of having the best of both worlds—the “live” classroom environment and the efficient, easily accessible VLE component—in the blended learning environment helped students improve their performance more than those who only had access to the classroom environment. Although the group with no access to the VLE performed as well as the mandatory and optional use groups, the use of the VLE allowed users to draw near to the performance of the other group. The idea of learner control, in line with Gagné (1985) and Piccoli et al. (2001), was also found to play a key role in the extent to which the VLE was used. These results and their implications are discussed below.

**Blended Learning: The Best of Both Worlds**

In decision making contexts, the importance of costs in accessing high-quality information cannot be ignored (Culnan, 1984). We found this idea to be valid in learning contexts as well. Undoubtedly, as has been demonstrated in a variety of learning
In this study, each method of "retaining" a lecture has its costs; for instance, notes fail to capture the verbal interactions entirely while audio-recordings, though accurate, may be cumbersome. Thus, notes offer a low-cost/low-value option for accessing information (Gagné, 1985), while recordings offer a high-cost/high-value option. The Web-enabled session-replay system implemented in this study provided the same content of the lecture (including the questions raised in class) in very much the same format as the lecture, with visual focus on the slides and verbal focus on the discussion. Compared to the other methods of accessing information, the VLE is a low-cost/high-value option. It also offers the added benefits of random access and key-word searches, so learners can focus on easily seeking out information that is unclear to them.

**The Learner as Decision Maker**

While traditional learning research began with an instructor-centric view, early e-learning research began at the other end of the spectrum, i.e., with a learner-centric view (Jarvenpaa and Leidner, 1995). The assumption with this research paradigm was similar to that of the traditional learning model, albeit in favor of the learner. Thus, learners were viewed as seeking out sources of knowledge with which they would interact to achieve their learning goals.

The blended learning model combines both the instructor-centric view and the learner-centric view given its dual emphasis on traditional and technology-mediated learning. The in-class lecture mode is consistent with the instructor-centric view that delivery of content matters. While the value of this medium was never in question—as confirmed by the fact that those students who only had access to the classroom lectures performed well throughout the semester—its cost was. The VLE component delivers the same content as the lecture and in the same format, but with lower access costs.

Interestingly, the value of the VLE component was in enabling its users to play “catch up” with those who did not use it. Evidence of the learner-centric view is apparent from the test of hypothesis H3. Poor performance in the midterm exam was strongly related to the extent to which a learner used the VLE. The prevailing learner-centric view suggests that users will seek out and explore content in an effort to meet their learning goals. In this case, learners—motivated by the desire to improve their performance—looked to the VLE as a readily accessible, high-value/low-cost option and used it to meet their goals. Thus, the empirical findings of Piccoli et al. (2001) and the theoretical arguments of Gagné (1985) are consistent with our findings that learners will act as decision makers—examining the costs and benefits of accessing information sources—and where the benefits exceed the costs of such access, will, as Mooers (1959) proposed, use it.

**Implications for Teaching and Practice**

Results of this study suggest that physical information accessibility does indeed play a role in blended learning. It lends support to the information-processing model of learning whereby learners choose to utilize alternative sources of information based on an analysis of their costs and benefits. A key implication is that leveraging the Web’s fundamental benefit of convenience alone can lower learners’ costs below a threshold that justifies the access effort and brings them in contact with high value content that might otherwise be forsaken at the expense of performance. The reality of diminishing student effort highlights the value of leveraging accessibility-enhancing technologies to help learners maximize efficiency and get the most for the time they do invest. Results of this study suggest blended learning may offer a way to improve students’ return on time invested in learning.

The results of this study also have practical significance for managers involved in making decisions about technology support for training and learning activities. Blending VLE with traditional learning can help organizations leverage their investments in training programs. In a real sense, these organizations can reap the benefits of both worlds—having “live” training sessions which offer all the advantages of such a medium (but are short lived) and accessible, low-cost session replays which replicate this experience, but have a considerably longer life span. Over the long term, an organization can build a library of such digital resources, which can enhance employee learning and improve their performance. Recent reports (e.g., “The Trouble with Online College,” 2013) suggest that many organizations are starting to follow this approach.

**CONCLUSION**

Until recently, the traditional classroom experience with all its attendant benefits and the e-learning environment with its emphasis on efficiency were seen by many as mutually exclusive options. However, blended learning brings these options together and may offer the best of both worlds. Results of this study provide initial support within a limited context that the use of blended learning can help improve the performance of learners. Researchers and practitioners continue to struggle in identifying the “optimal” blend of classroom and online technology (Arbaugh, 2008); use of the VLE in this study is just one such example. More systematic studies of organizational learning and training efforts are needed to validate the effectiveness...
of blended learning in different settings. We conclude with this observation: Learning is necessarily a complex activity, one where the student and instructor are involved in an ongoing process of information exchange, and as with any exchange, there are costs and benefits associated with it. Reducing the costs of accessing this information is likely to enhance the learning process and improve its outcomes.
REFERENCES


