Maximizing Learning Outcomes from Web-Based Training: A Meta-Analysis

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Web-based instruction (WBI) is becoming a favored training option in industry, government, and higher education. In a survey of organizations in the American Society of Training and Development's benchmarking service, the percentage of companies using technology-delivered training increased from 8% in 1999 to 27% in 2004, and about 75% of the technology-delivered courses in 2004 were online (Sugrue & Rivera, 2005). Given its growing popularity, it is important to understand whether or not this delivery medium is effective, whether it is more effective than other delivery media, and what contextual or methodological factors moderate its effectiveness.

There are three goals for the current paper. First, we will compare WBI and face-to-face classroom instruction (CI) in terms of their effectiveness for teaching declarative knowledge (i.e., knowledge of the facts and principles taught in training) and procedural knowledge (i.e., the ability to perform the skills taught in training). Second, we will compare trainees' reactions to the two delivery media. Third, we will examine the effect of five training design characteristics on the effectiveness of WBI relative to CI for teaching declarative knowledge. Understanding the effect of course design characteristics will provide a practical guide to designers of Web-based training programs. In the following section, we define the course characteristics and propose several hypotheses and research questions that guided the present investigation.

Course Design Features

Instructional Methods. Instructional methods refer to techniques used within a course to convey course content such as lecture, textbook readings, assignments, or group discussions. When switching to an online training platform, many organizations create a mirror image of their classroom courses. That is, WBI and CI utilize similar instructional methods. WBI and CI have similar instructional methods when all of the instructional methods included in CI have a comparable instructional method in WBI. For example, when lecture is provided in CI a comparable instructional method in WBI is an online video of the lecture. WBI and CI have different instructional methods when an instructional method is present in WBI or CI and there is not a comparable instructional method in the other delivery medium.

Clark (1983; 1994) has argued that media studies often confound delivery media (i.e., technological devices used for the purpose of instruction such as computers, video-teleconferencing, and the Internet) with instructional methods, making it impossible to determine whether main effects are due to differences in media or instructional methods. Clark has argued that delivery media are inconsequential in affecting learning outcomes, especially when compared to more powerful influences such as individual differences and instructional methods. We tested Clark's theory by isolating studies that compared WBI to CI but used identical instructional methods. Support for Clark's theory would be evident in no difference between WBI and CI when instructional methods are the same across courses. Consistent with Clark's theory, the first hypothesis is: *Similarity of the instructional methods used in WBI and CI will moderate learning declarative knowledge from WBI relative to CI. That is, any effects observed for all studies will disappear when examining only studies where similar instructional methods were used in WBI and CI.*

Human Interaction. Human interaction refers to the extent to which trainees interact with the instructor and other trainees throughout the course. In the current study, we coded whether WBI and CI were high or low on human interaction. Low human interaction indicates less than half of the course involved interacting with others. An example is a Web-based course in which trainees participate in an online discussion once a week or less. High human interaction indicates all or most of the course involves interacting with others. An example is a Web-based course in which trainees frequently work on group projects and participate in online discussions.

A number of studies have found that higher levels of interaction between instructors and learners or among learners result in greater learner motivation, more positive attitudes towards learning or the instructional process, and improved learning outcomes (e.g., Entwistle & Entwistle, 1991). Thus, the second hypothesis is: *Human interaction will moderate the extent to which trainees learn declarative knowledge from WBI relative to CI. Relative to CI, trainees will learn more declarative knowledge from WBI with high levels of human interaction than with little human interaction.*

Learner control. Learner control refers to the extent to which trainees have control over their learning experience by affecting the content, sequence, or pace of material (Friend & Cole, 1990). In the current study, we coded whether WBI and CI were high or low in learner control. Low learner control indicates trainees have little or no control over the content, sequence, or pace. Examples of Web-based courses with little or no control are non-interactive lecture-based classes and computer-controlled sequences of activities completed in a set amount of time. High learner control indicates trainees have at least some control over two of the three dimensions (pace, content, or sequence) or a high level of control over one dimension. Examples of courses with high levels of control are a managerial course where trainees can select material that is relevant to their jobs or an online tutorial that trainees can access whenever they need to practice job-related skills.

Previous research consistently finds that adults react favorably to receiving control during instruction (e.g., Kraiger & Jerden, in press). However, research also shows that the effect of learner control on actual learning is either negligible or non-existent (Kraiger & Jerden, in press; Niemiec, Sikorski, & Walberg, 1996). This research suggests that while learners like to control the means by which they engage instructional material, they do not necessarily benefit from it. Thus, we proposed the following research question: *Will the level of learner control moderate learning of declarative knowledge in WBI relative to CI? Relative to CI, will participants learn more declarative knowledge with low or high levels of learner control in WBI?*

Practice and Feedback. Both the opportunity to practice and feedback were included in Kraiger's (2003) guidelines for designing effective training. Practice is essential for skill acquisition and feedback is needed for trainees to know whether they are effectively using their newly acquired knowledge and skills (Brown & Ford, 2002). Further, Azevedo and Bernard (1995) conducted a meta-analysis of 22 computer-based training studies and found students who were given feedback learned more than students who were not given feedback. Thus, the relative effectiveness of WBI and CI is contingent upon whether one or both delivery media incorporated practice and feedback during training. Thus, the third and fourth hypotheses are: *Practice and feedback will moderate the extent to which trainees learn declarative knowledge from WBI relative to CI. Relative to CI, trainees will learn when more declarative knowledge when they practice during WBI (H3). Relative to CI, trainees will learn when more declarative knowledge when they receive feedback during WBI (H4).*

Research Methodology

A thorough review of the training and education literature from 1996-2005 was conducted. The goal of the literature search was to identify research and technical reports that compared the effectiveness of WBI

and CI for delivering training courses on the same topic. Ninety-six studies with relevant effect sizes have been identified and coded. Together, the articles reported data on 19,331 trainees who took part in 168 training courses, such as engineering, computer programming, business, and technical writing courses. In 67% of courses the trainees were undergraduates, while the trainees were graduate students (18% of courses) or employees (15% of courses) in the remaining courses. Across all of the studies that provided demographic information, the average age of participants was 24 years and 41% of the participants were male.

The Hedges and Olkin's (1985) approach was used to analyze the data. Effect sizes were corrected for small sample bias and attenuation and each of the effect sizes was weighted by the inverse variance to calculate the weighted mean effect size for each of the outcome variables. The letter *d* is used to represent an effect size. In the current study, a positive *d* effect indicates WBI is more effective than CI and the larger the number the more the Web group is outperforming the classroom group. If *d* equals 0, it indicates WBI and CI are equally effective on the criteria of interest. A negative *d* indicates CI is more effective than WBI and the more negative the number the more the classroom group is outperforming the Web group.

Next, the moderating effects of the three categorical moderators (similarity of instructional methods, human interaction, and learner control) were tested by classifying the studies according to the moderator categories and testing for mean differences between the high and the low moderator categories. The similarity of instructional methods, practice, and feedback moderator analyses utilized information about both the Web-based and classroom courses in the analyses. For investigations of learner control and human interaction, we held characteristics of CI constant. We focused our learner control moderator analysis on classroom courses low in learner control. This allowed us to compare effect sizes between WBI high and low in learner control. All of the classroom courses were high in human interaction, allowing us to compare effect sizes between WBI high and low in human interaction.

Results

The first goal of the current study was to compare the effectiveness of WBI and CI for teaching declarative and procedural knowledge. The results indicate that overall, WBI was 6% more effective than classroom instruction for teaching declarative knowledge ($d = .15$). However, the procedural knowledge effect size was near zero ($d = -.07$) and the confidence interval contained zero, suggesting WBI and CI were equally effective for teaching procedural knowledge.

The second goal of the current study was to compare trainees' reactions to WBI and CI. The results indicate trainees were equally satisfied with the two delivery media ($d = .00$). However, the majority of studies that have been conducted compared differences in declarative knowledge between WBI and CI. Seventy-one effect sizes were included in the declarative knowledge analysis, 15 effect sizes were included in the procedural knowledge analysis, and 22 effect sizes were included in the reactions analysis. Thus, we can have greater confidence in the declarative knowledge analysis and the remaining analyses will focus exclusively on declarative knowledge.

The first hypothesis predicted WBI and CI would be equally effective for teaching declarative knowledge when the same instructional methods were used. The declarative knowledge effect size was near zero when the same instructional methods were used to deliver WBI and CI ($d = .04$), supporting hypothesis one. However, WBI was 11% more effective than CI for teaching declarative knowledge when different instructional methods were used to deliver the two courses ($d = .29$). This pattern of results supports Clark's (1983, 1994) theory that instructional methods rather than delivery media determine whether students learn during training.

The second hypothesis predicted trainees would learn more with high levels of human interaction than with low levels of human interaction during WBI. WBI was equally effective with high and low level of human interaction (d = .18 & .19, respectively), failing to support hypothesis two. However, it is possible that various forms of communication (e.g., discussion boards, chat rooms, and e-mail) differ in their effect on learning from WBI. To address this concern, we examined whether synchronous and asynchronous communications differ in their effect on learning declarative knowledge from WBI. The results indicate synchronous communication is more beneficial for learning from WBI than asynchronous communication. Thus, there is evidence that same-time communication facilitates learning during WBI.

The results indicate trainees learned more declarative knowledge with a high than a low level of control during WBI (d = .30 & .07, respectively). Trainees learned 12% more declarative knowledge from WBI than CI when they had a high level of control during WBI.

The third hypothesis predicted classes that provided practice would be more effective than classes that failed to provide practice. The effect size was largest when WBI but not CI included practice (d = .31), indicating WBI was 12% more effective than CI for teaching declarative knowledge when WBI but not CI provided trainees with the opportunity to practice the course material. WBI was also more effective than CI when both delivery media incorporated practice (d = .16), but was less effective than CI when WBI failed to incorporate practice during training (d = -.27 when CI included practice and -.25 when CI did not include practice). Overall, the results suggest practice is beneficial in both WBI and CI, supporting hypothesis three.

Hypothesis four predicted feedback would moderate the relative effectiveness of WBI and CI, and classes that provided feedback would more effective than classes that failed to provide feedback during training. The effect size was largest when WBI but not CI included feedback (d = .33) followed by the effect size where both WBI and CI provided feedback (d = .16). In both of these instances WBI was more effective than CI for teaching declarative knowledge. In addition, the effect size approached zero (d = .08) when neither WBI nor CI provided feedback to trainees and was negative when CI but not WBI included practice (d = -.27). Thus, the results indicate feedback is beneficial during both WBI and CI, supporting hypothesis four.

Conclusions

Meta-analytic procedures were used to examine the effectiveness of WBI compared to CI for teaching declarative and procedural knowledge and for trainee reactions. Across all studies, the results indicated WBI was 6% more effective than CI for teaching declarative knowledge. These results are based on 71 effect sizes and 10,910 learners. WBI and CI were equally effective for teaching procedural knowledge and trainees were equally satisfied with the two delivery media.

However, Clark (1983; 1994) argued that there is nothing uniquely advantageous to any delivery medium, so we should expect no effects in well-designed media comparison studies. Our results support Clark's position that media effects in single study research are largely spurious. In the current meta-analysis, WBI and CI were equally effective for teaching declarative knowledge when similar instructional methods were used to deliver the two courses, supporting Clark's theory. This suggests that instructional methods are driving observed differences in the effectiveness of WBI relative to CI.

We also investigated the effect of several course design characteristics on the effectiveness of WBI relative to CI. Across studies, the extent to which Web-based trainees learned more than classroom trainees was greatest when Web-based trainees were provided with control, when trainees practiced the training material, and when trainees received feedback during training. Thus, attention to course design features is critical for maximizing learning outcomes. The results we report can be used in conjunction

with accurate estimates of the cost of implementing and maintaining online instructional programs to estimate the utility of converting CI to WBI.

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