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Research Report 1802

The Effectiveness of Web-based Training

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14. ABSTRACT *(Maximum 200 words)*:

As the Army focuses more on Web-based instruction as a delivery option for training, professional development, and education, it is important to understand its instructional effectiveness. A search of the literature between 1996 and 2002 identified more than 500 reports concerning Web-based courses, that is courses delivered over the Internet or an intranet and conveyed through a browser. Most concerned recommendations for design or technology issues rather than empirical measures of learning outcomes. From this larger set, 47 studies reported empirical measures of outcomes; of these, 15 studies reported data with sufficient detail to compute an effect size. The effect size, comparing Web-based instruction to conventional classroom instruction, was .24, which means the “average” student moved from the 50^{th} to the 59^{th} percentile. In earlier analyses of the effectiveness of other forms of computer-based instruction, effects sizes of between .32 and .41 have been reported (corresponding to the 63^{rd} and 66^{th} percentiles). In terms of instructional effectiveness, it appears that current practices in Web-based instruction improve learning when compared to the classroom, but many more complete studies are needed before the full effect size is understood.

15. SUBJECT TERMS

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Research Report 1802

The Effectiveness of Web-Based Instruction

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FORWORD

The U.S. Army Research Institute is examining the use of distributed learning technologies for use by soldiers in an “on demand” environment, where training becomes more soldier centered rather than classroom based. Part of the work involves a thorough assessment of the distance learning research literature as it pertains to training. The present report under ARI’s WEBTRAIN project provides an examination of empirical evidence concerning the effectiveness of Web-based instruction. It forms a foundation for guidelines to help training developers, training managers, and policy makers.

The results of this research were presented to the Army Training and Doctrine Command, Deputy Chief of Training, on 17 October 2002.

Franklin L. Moses
Acting Technical Director

THE EFFECTIVENESS OF WEB-BASED INSTRUCTION

EXECUTIVE SUMMARY

Research Requirement:

The Army is embarking on a major change to deliver standardized individual, self-development, and small group training to soldiers through the application of networked communication systems. Planning calls for Army training to become more learner-centric, in which soldiers assume increased responsibility for the acquisition of knowledge and the development of skills, delivered over the Internet or military intranets. Reports in the literature on the effectiveness of instruction delivered over the Web have begun to appear, but there has not been an integrated analysis of these early findings. This report offers an initial analysis of the reported findings.

Procedure:

Searches on relevant research databases yielded 40 reports with learning outcome data from the more than 500 reports on the topic of Web-based instruction. When including multiple studies documented in some reports, the number of cases that provided empirical evidence increased to 47. Of these, 15 provided sufficient data to compute an effect size, a standard way of quantifying differences between groups. Here, the groups refer to a comparison group that received instruction in a conventional classroom and an experimental group that received comparable instruction over the Web.

Findings:

The average effect size, comparing Web-based instruction to conventional classroom instruction, was .24, which means the "average" student moved from the 50th to the 59th percentile. The relatively small number of studies reporting outcome data demonstrated wide variability; the effect sizes ranged from -.4 to 1.6. In earlier analyses of the effectiveness of non Web-based forms of computer-based instruction that used hundreds of studies, effects sizes of between .32 and .41 have been reported (corresponding to the 63rd and 66th percentiles). In terms of instructional effectiveness, it appears that current practices in Web-based instruction lead to an improvement in learning when compared to the classroom, but the central tendency falls short of that for traditional computer-based instruction. In view of the shortage of empirical findings and the relative novelty of using the Web for instructional purposes, dozens of more controlled studies are needed before a more accurate effect size can be resolved. There is no practical reason why the effect size should be less than that demonstrated for computer-based instruction.

Utilization of Findings:

These findings can be used as a basis for (1) selecting best practices in an objective manner, (2) establishing objective performance criteria for future learning content, and (3) creating an initial data set to which future evidence on the effectiveness of Web-based instruction can be added.

THE EFFECTIVENESS OF WEB-BASED INSTRUCTION

CONTENTS

LIST OF TABLES

THE EFFECTIVENESS OF WEB-BASED INSTRUCTION

The U.S. Army plans to increase the use of distributed learning to meet the future training needs of a responsive and versatile force. The goals of the Army Training and Doctrine Command are to provide digital training facilities within 50 miles of 95 percent of Army duty stations and develop more than 525 distributed learning courses. The courses will encompass online instruction distributed over communication networks, blended to varying degrees with CD-ROM, print material, email and chats, and conventional hands-on instruction and testing as needed. For the versatile force of the future, learning will be centered around the soldier instead of the classroom. A central question, then, is just how effective is online instruction? In particular, how does it compare to both the conventional classroom and established forms of stand-alone, computer-based instruction (CBI) prior to the World Wide Web?

For the purposes of this review, online instruction is considered to be any educational or training program distributed over the Internet or an intranet and conveyed through a browser, such as Internet Explorer™ or Netscape Navigator™. Hereafter, it is referred to as Web-based instruction. The use of browsers and the Internet is a relatively new combination in instructional technology. While the effectiveness of traditional CBI has been reviewed quite thoroughly (Kulik, 1994; Lou, Abrami, & d'Apollonia, 2001), the effectiveness of online instruction has received little analysis. Part of the reason is because few cases have been detailed in the literature. This report serves, then, as an initial look at the empirical evidence for its instructional effectiveness.

Advantages of Training Technology

The Army seeks to take advantage of the benefits offered by distributed learning, such as reduced travel costs, increased accessibility, and improvements in learning. The cost advantage of even basic forms of technology-based instruction has been documented (Fletcher, 1990; Wisher, Priest, & Glover, 1997). Learning advantages have consistently been found whenever well-designed instruction is coupled with computer delivery. Fletcher (2001), for example, has established the "Rule of Thirds" based on an extensive review of the empirical findings in educational and training technology. This rule advises that the use of CBI reduces the cost of instruction by about one-third, and additionally either reduces the time of instruction by about one-third or increases the effectiveness of instruction by one-third. The analysis for this rule was based primarily on stand-alone CBI, not the contemporary use of online technologies.

There is no practical reason to expect Web-based instruction to be any less effective than traditional CBI. Both are capable of interactivity, individual feedback, and multi-media presentation. However, technical limitations with current Web-based configurations may dilute some of these advantages. Inherent limitations such as a small viewing area for video, video with a slow frame speed, or delays in responsiveness as a result of high traffic load on the Internet may restrict its current effectiveness. On the other hand, Web-based instruction offers new advantages to the learner, such as interactivity with instructors and students and quick access to supplementary online resources. As the technology improves, Web-based instruction may have an ultimate advantage.

This report first reviews the numerous ways in which the World Wide Web is influencing instructional practices. Then, the parameters for and results of a search on the evaluation literature are described. The results of a meta-analysis of the evaluation data are reported and a central tendency of instructional effectiveness is identified. How well this central tendency, represented as a standardized effect size, compares to both the conventional classroom and to traditional uses of the computer as a stand-alone delivery device is discussed. Finally, some conclusions are drawn from this initial inquiry into the effectiveness of Web-based instruction.

The Use of the World Wide Web In Course Instruction

The World Wide Web can be used in various ways for instructional and instructional support purposes. For example, Web-based instruction offers the learner unparalleled access to instructional resources, far surpassing the reach of the conventional classroom. Web-based instruction also makes possible learning experiences that are open, flexible, and distributed, providing opportunities for engaging, interactive, and efficient instruction (Kahn, 2001). Phrases such as “flexible navigation,” “richer context,” “learner centered,” and “social context of learning,” are populating the literature on Web-based instruction. Furthermore, the rendering of cognitive-based theories of learning into the terminology of Web-based instruction extends the technical nomenclature to actual instructional practices (Bonk & Dennen, 1999). Indeed, Dills and Romiszowksi (1997) have identified more than 40 instructional paradigms seeking to advance and improve the online learning experience beyond the conventional classroom.

Some researchers have argued, however, that the tried-and-true principles of instructional design, namely interaction and timely feedback, are often absent from Web-based instruction, particularly from individual websites devised to teach (Eli-Tigi & Branch, 1997). The absence of a sturdy pedagogical underpinning for a Web-based program can diminish an otherwise worthy opportunity to improve learning. Well-designed CBI developed in the 1970s and 1980s, for example, has demonstrated an enhancement to learning outcomes when compared to classroom instruction (Kulik & Kulik, 1991). How does Web-based instruction compare to the classroom at this relatively early stage of its implementation? In view of the extraordinary potential for Web-based instruction, it is somewhat surprising that there are few empirical assessments of its effectiveness.

Unlike the fixed resources in conventional CBI, Web-based instruction can be conveniently modified and redistributed, readily accessed, and quickly linked to related sources of knowledge. This establishes a backbone for “anytime, anywhere” learning (Fletcher & Dodds, 2001). Compare these features to, say, a pre-Internet CD-ROM in which instructional messages were encoded in final form, availability was limited to specific computers, and immediate access to a vast array of related materials was not possible. To be sure, many key instructional features, such as learner control and feedback, are shared between Web-based and conventional CBI.

A reasonable assumption concerning the effectiveness of Web-based instruction, then, is that it should be at least “as good as” conventional forms of CBI. That is, the effect size of evaluations that compare the effectiveness of either to the classroom should be comparable. The qualities shared by the two delivery media include multi-media formats, self-pacing, tailored feedback, and course management functions. Additionally, the unique features of Web-based instruction – flexible courseware modification, broad accessibility, and online links to related materials, instructors, and fellow students – should make possible improvements in learning outcomes beyond what CBI has demonstrated. Within the CBI literature as described in detail shortly, the learning outcomes (when compared to conventional classroom instruction) have demonstrated effect sizes of between 0.3 and 0.4 standard units (Fletcher, 1990; Kulik, 1994).

The measure of effect size is simply a way of quantifying the difference between two groups. For example, if one group had an experimental treatment (Web-based instruction) and the other did not (the conventional classroom), then the effect size is a measure of the effectiveness of the Web-based treatment compared to that of the classroom. In statistical terms, the effect size describes the difference between two group means divided by either the pooled standard deviation or the standard deviation of the treatment group (Glass, McGaw, & Smith, 1991). An advantage of using effect size is that numerous studies can be combined to determine an overall best estimate, or central tendency, of the effect. Generally, values of 0.2, 0.5, and 0.8 standard units are considered to correspond to small, medium, and large effect sizes, respectively (Cohen, 1988). (N.B. Effect sizes can be quickly translated to percentiles from a table of standard distributions.) Our premise in the present analysis is that if Web-based instruction is employed properly, and in a similar manner to conventional CBI, it should lead to an effect size that is comparable to that demonstrated for CBI. The assumption of being "as good as" CBI is reasonable, of course, when the Web is applied for purposes similar to conventional CBI, namely for achieving specific learning objectives.

Roles of the Web In Instructional Settings

Web-based instruction presents multiple dimensions of use in education and training environments. As with CBI, it is capable of providing direct instruction to meet individual learning objectives. Due to its networking capability, the Web can assume additional roles. These include promoting and facilitating enrollment into courses, availing the syllabus or program of instruction, posting and submitting assignments, email between instructors and fellow students, collaboration on assignments, and building learning communities.

The Web has become a powerful tool for learning and teaching at a distance. Its inherent flexibility allows application in a variety of ways within an educational context, ranging from simple course administration and student management to teaching entire courses online. Each of these "levels of use" works towards a different goal. These goals should be recognized when evaluating the use of the Web. For example, an instructor may hold face-to-face lectures in a classroom but post the class syllabus, assignments, and grades on the Web. In this case, it would not be appropriate to evaluate the use of the Web with respect to learning outcomes, since the Web was not used in a direct instructional role.

There are a host of factors that contribute to a meaningful learning environment. In an attempt to gain a systematic understanding of these factors, Kahn (1997) developed a framework for Web-based learning, consisting of eight dimensions: pedagogical, technological, interface design, evaluation, management, resource support, ethical, and institutional. Kahn (2001) later offered a framework for the extent of Web-based instruction along a continuum ranging from "micro" uses to "macro" uses. The "micro" end of the continuum involves the use of the Web as a way to supplement or enhance conventional classroom instruction (e.g., providing students in a biology course with an interactive map of the brain to help them learn brain functions). Further along the continuum are courses that are partly delivered over the Web, such as elective modules that supplement classroom instruction. Clearly, factors beyond pedagogy such as technical reliability, interface design, and evaluation become more important at this level. Finally, at the "macro" end of the continuum are complete distance learning programs and virtual universities.

Other researchers have recognized the importance of determining the level of Web-use in a course. For example, Galloway (1998) identified three levels of Web-use. In Level 1, the Web is used to post course material with little or no online instruction. The instructor guides students to the relevant information rather than obliging the students to search for information. In Level 2, the Web is used as the medium of instruction. Course assignments, group projects, and lecture notes are posted on the Web. The teacher becomes the facilitator of knowledge, guiding the student rather than telling them what to do. In addition, there is increased student-student interaction. Courses that are offered completely online fall into Level 3. Teachers and students interact only over the Internet, and knowledge of using the technology is extremely important at this level.

Web-based instruction is still in an early stage of implementation. Nevertheless, educational institutions, private industry, the government, and the military anticipate immense growth in its use. In its 1999 distance education statistical analysis, for example, the National Center for Education Statistics found that 82% of higher education institutions plan to increase their use of Web-delivered courses (Johnson, 2001). In addition, it is estimated that by 2003, approximately $11.4 billion will be spent for online training and more than 30% of corporate education will be conducted online (Bonk & Cummings, 1998).

Obstacles to realizing the Web's full potential for learning clearly remain. These include the appropriateness of pedagogical practices (Fisher, 2000) and the bandwidth bottleneck for certain learner requests, for example video on demand (Saba, 2000). From an evaluation perspective, there has been an inclination for media comparison, such as the effectiveness of a technology relative to the conventional classroom (Wisher & Champagne, 2000). However, the more appropriate benchmark might be a comparison to the historical findings on the effectiveness of conventional CBI. An assessment of current practices, then, must consider whether the capabilities of the Web are being tapped, how interpretable the findings are, and how strong those findings are in comparison to conventional CBI.

The Effectiveness of CBI

CBI has been a significant part of educational technology, beginning with the first reported use of the computer instructional purposes in 1957 (Saettler, 1990). Its emergence as a true multimedia delivery device occurred in the early 1980s with the coupling of a videodisc player with a computer. In recent years, the videodisc has been replaced by the CD-ROM. The combination of a computer controlling quality video and/or audio segments was a compelling advancement in CBI, and the instructional effectiveness of this pairing has been documented.

Since our premise is that Web-based instruction should be at least "as good as" conventional CBI, a summary of the findings is needed in order to identify a comparative benchmark.

Fletcher (1990) conducted a quantitative analysis of the education and training effectiveness of interactive videodisc instruction. Specifically, empirical studies comparing interactive videodisc instruction to conventional instruction were segmented into three groups: higher education, industrial training, and military training. The various learning outcomes investigated included: (1) Knowledge outcomes, which assessed a student's knowledge of facts or concepts presented in the instructional program; (2) performance outcomes, which assessed a student's skill in performing a task or procedure; (3) retention, which measured the durability of learning after an interval of no instruction; and (4) the time to complete the instruction. The effect sizes, or the difference between the mean scores of the treatment and comparison groups divided by the standard deviation of the control group, were computed for each of the 28 studies identified.

The results of the Fletcher (1990) meta-analysis are presented in Table 1, broken down by learning outcome, and in Table 2, broken down by instructional group. The effect sizes are reported in standard units with a corresponding percentile from a normal distribution.

Table 1
Average Effect Sizes for Four Types of Knowledge Outcomes for CBI

Learning Outcome	Effect Size	Percentile
Knowledge	.36	64th
Performance	.33	63rd
Retention	.65	74th
Time to Complete	1.19	88th

Table 2
Average Effect Sizes for Three Instructional Groups Using CBI

Instructional Group	Effect Size	Percentile
Higher Education	.66	74th
Industrial Training	.17	57th
Military Training	.39	65th

The conclusion of the Fletcher (1990) analysis was that interactive video instruction was both effective and less costly than conventional instruction.

In a later analysis of the effectiveness of CBI, Kulik (1994) took into account the conceptual and procedural differences in how the computer was used in the individual studies. In his analysis of 97 studies that compared classes that used CBI to classes that did not, Kulik (1994) computed the overall effect size as well the effect sizes corresponding to five categories of computer use relevant to the present report: 1) tutoring, 2) managing, 3) simulation, 4) enrichment, and 5) programming.

Kulik determined the overall effect size to be .32. This indicates that the average student receiving CBI performed better than the average student in a conventional class, moving from the 50^{th} percentile to the 62^{nd} percentile. However, the effect sizes when categorized by computer-use yielded somewhat discrepant results. These results are presented in Table 3.

Table 3
Average Effect Sizes for Six Categories of CBI

Application	Effect Size	Percentile
Tutoring	.38	65^{th}
Managing	.14	56^{th}
Simulation	.10	54^{th}
Enrichment	.14	56^{th}
Programming	.09	53^{rd}

The effect size for computer-based programs used for tutoring (.38) is significantly higher than the rest, indicating that students who use computers for these purposes may achieve better outcomes than students who use CBI for management, simulation, enrichment, or programming purposes. In addition, it is clear from the table that basic programming and simulations had minimal effect on student performance. The conclusion of the Kulik (1994) analysis was that researchers must take into account all types of CBI when trying to assess their effects on student learning.

Finally, Liao (1999) conducted a meta-analysis of 46 studies that compared the effects on learning of hypermedia instruction (e.g., networks of related text, graphics, audio, and video) to different types of non-hypermedia instruction (e.g., CBI, text, conventional, videotape). Results indicated that, overall, the use of hypermedia in instruction results in more positive effects on students learning than non-hypermedia instruction with an average effect size equal to 0.41. However, the effect sizes varied greatly across studies and were influenced by a number of characteristics. Effect sizes were larger for those studies that used a one-group repeated measure design and simulation. In addition, effect sizes were larger for studies that compared hypermedia instruction to videotaped instruction than for studies that compared hypermedia instruction to CBI. These results seem to suggest that the results of hypermedia instruction greatly depend on the type on instruction that it is compared to.

While each of the studies reviewed above provides evidence for the positive effects of CBI on student learning, they also address the complexity of the issue. The relationship between CBI and learning is influenced by many variables including the type of media being used, what CBI is being compared to, and the type of research design employed, to name just a few. These issues increase in complexity when applied to Web-based instruction as instruction becomes less linear and more interactive and dynamic.

The Effectiveness of Web-Based Instruction

The review encompassed 40 articles published between 1996 and 2002. A tabulation of the documented findings into nine dimensions are offered in Appendix A, along with our assessments of the experimental designs, effect sizes, and the degree to which the evaluation incorporated features unique to Web-based instruction. The studies are first discussed in terms of four key features: 1) the degree of interaction in the course; 2) the measurement of learning outcomes; 3) the experimental design used in evaluating the course; and 4) the extent of Web use throughout the course. Since the purpose of this review is to assess current practices in the use and evaluation of Web-based courses, the criteria that guided the choice of studies for this review were broadly defined. The studies had to involve the use of the Web as an instructional tool either as a supplement to conventional classroom instruction or as the primary medium of instruction. In addition, the studies had to include an evaluation of the Web-based components of the course. The studies were directed at the undergraduate and graduate levels of education.

The evaluations include in these studies fell into two broad categories. The first category of evaluation consisted of comparisons of Web-based instructional approaches to conventional classroom instruction. These evaluations could involve the comparison of a control group with an experimental group derived from the same population of students or a simple comparison between a class taught at one time without the use of the Web and the same class taught at a different time using the Web. The second category of evaluations involved the assessment of student performance and reactions relative to a single course.

Methods and Procedure

The Educational Resources Information Center (ERIC) and Psychological Abstracts databases were searched using the following combinations of key words: “web-based courses,” “web-based instruction,” “web-based courses and evaluation,” “course evaluation and web,” “course evaluation and Internet,” “web and distance education,” and “online course and evaluation.” Because we were trying to assess current practices in evaluating Web-based instruction, the search was restricted to the years between 1996 and 2002. This search, conducted between August 2000 and July 2002, identified more than 500 qualifying studies. However, most of these studies concerned recommendations for the design of online courses or technology concerns rather than an evaluation of a specific course, so they were not included in the review. In addition, we found several relevant studies from the *Journal of Asynchronous Learning*, *Education at a Distance*, and the previous four years of the *Proceedings of the Distance Teaching and Learning Conference*. Finally, we received useful references and citations from researchers in the field of distance education that had not been identified by our search of the databases.

We narrowed the larger set of studies to 47 based on reports of empirical evidence for instructional effectiveness. These are summarized in Appendix A, which is organized alphabetically by the first author's last name. Although most of the studies involved courses in the physical sciences, the instructional content of the courses concerned a variety of subject matters, including philosophy, nutrition, economics, and sports science.

Our review of the literature on Web-based instruction is organized according to three categories: 1) study characteristics, 2) methodological characteristics, and 3) course characteristics. The analysis of these characteristics provides some insight into what questions people are asking about Web-based instruction and how well they are being answered. Descriptive statistics for these characteristics are presented in Table 4.

Table 4
Descriptive Statistics for Studies Included in Review

Variables	N	%		Variables	N	%
Content Area				**Course Characteristics**		
Math/Engineering/Computers	11	23		Level of Web Use		
Science/Medicine	12	26		All-Online	29	62
Distance Education Programs	7	15		Blend	17	36
Social Sciences/Education	11	23		Mixed between courses	1	2
Business	4	9				
Language	2	4		Attrition Data		
				Yes	18	38
Educational Level				No	29	62
Undergraduate	38	81				
Graduate	8	17		Variables Assessed		
Both	1	2		Course design	21	45
				Demographics	22	47
Methodological Characteristics				Computer Experience	13	28
Sample Size				Effectiveness of instructor	18	38
9-50	13	28		Technical issues	12	26
51-100	10	21		Interaction/Participation	12	26
Over 100	13	28		Desire to take additional online	6	13
Not Reported	11	23		Recommendation of course to others	3	6
Comparison Group						
Yes	29	62				
No	18	38				

Study Characteristics

Content Area

Content areas represented in the studies were wide-ranging. Approximately 23% examined the effects of Web-based instruction for teaching math, engineering, and computer courses whereas 26% focused on the teaching of science and medical courses. Another 23% focused on the social sciences and education. In addition, about 15% of the studies evaluated entire programs of distance learning, which most likely were comprised of many types of courses. The wide variety of content areas discovered in this review demonstrates the flexibility of Web-based instruction to be adapted to the requirements of students and teachers in many different subject areas.

Educational Level

Both undergraduate and graduate students were represented in this review. Of the 47 studies, 81% evaluated Web-based instruction for undergraduate students, 17% evaluated graduate students, and 2% evaluated Web-based instruction combined for both graduate and undergraduate students. Given the differences in both course content and teaching styles between undergraduate classes and graduate classes, it would have been interesting to assess the differential impact of Web-based instruction on student learning between the two. However, insufficient information was provided by the studies to be able to draw any firm conclusions on this issue. For example, many of the studies failed to provide means or standard deviations for learning outcome measures. In addition, may of the studies with graduate students did not describe the methods used to assess student learning and performance or provide adequate descriptive information as to assess course content and level of Web use.

Methodological Characteristics

Sample Size

The sample size of a study can significantly affect the statistical power of the underlying tests for differences. Of the 47 studies, 36 reported information about the sample sizes of participants. These ranged from 9 to 1,406 (M = 153, SD = 245). Of these 36 studies that provided sample sizes, most (64%) had sample sizes of fewer than 100 participants. Effect sizes were available for 10 of these studies, and the mean effect size was approximately 0.09. For studies in which the sample size exceeded 100, the mean effect size increased to 0.55. In general, the larger the sample-size, the stronger the statistical power. However, since effect sizes were available for only 15 of the studies, these results must be interpreted with caution.

Use of A Comparison Group

The majority of the studies identified for this review used a comparison group in which students took the same course face-to-face or the same course with no Web-based components. However, 41% of the studies simply evaluated the Web-based course with no comparison group. A similar pattern was found in evaluations of distance learning technology in training environments in which 55% of evaluations did not use a comparison group (Wisher & Champagne, 2000). While a comparison group is not a requirement for course evaluation, the absence of one can threaten the internal validity of the study and restrict the interpretation of the data. It is difficult to draw conclusions about the impact of instruction using the Web on student learning, satisfaction, and other outcomes without an equivalent comparison group. Furthermore, of the 29 studies that had a comparison group, only one (Schutte, 1996) randomly assigned students to conditions. Thus, even most of the studies with comparison groups were subject to many possible confounding variables that may have influenced the relationships between Web-based instruction and learning outcomes.

Course Characteristics

Level of Web-Use

As demonstrated by the results of both Kulik (1994) and Liao (1999), different forms of CBI can differentially affect student outcomes. Thus, it is important to take into account how a particular medium of instruction is applied when evaluating a course. This is especially true of Web-based instruction in view of the medium’s tremendous ability to distribute seemingly unlimited resources and information to anyone at anytime. The flexibility of the Web allows it to be used for a variety of purposes, from course administration and management to complete course delivery, and each of these “levels of use” works towards a different goal.

All of the studies surpassed the use of the Web for purely management purposes. Of the 47 studies, 17 evaluated "blend courses" or courses that are a mix of both face-to-face instruction and Web-based components (e.g., posting of course syllabus and lecture notes, online tutorials and graphics, etc.). While the use of the Web in these "blend courses" fulfilled many management functions, students needed to access the Web regularly to be a productive member of the class. This access, in turn, caused higher levels of Web-use as defined by the frameworks described above. The remainder of the studies included courses that were completely online. At this level of use, there is little or no face-to-face interaction, so evaluating the degree of online interaction between students and instructors or other students, the availability of feedback, and technological issues becomes critical. Of the 30 courses that were completely online, 10 evaluated student and teacher interactions, the availability of instructor feedback, and technological issues. Since these variables are the cornerstones of good instructional design, regardless of delivery medium, it is important that they be included in any assessment of Web-based instruction.

In terms of learning outcomes, effect sizes were available for six of the "blend" courses and nine of the all-online courses. The mean effect size for the "blend" courses was 0.48 while the mean effect size for the all-online courses was 0.08. Although this is not a statistically significant difference (Mann-Whitney U Test, $p = .14$), the direction of the difference is the same as Liaos's (1999) analysis, which showed that the mean effect size for courses that used hypermedia as a supplement to conventional instruction was 0.18 standard units higher than courses that replaced conventional instruction with hypermedia. Taken together, the results appear to suggest that Web-based instruction may be more beneficial for student learning when used in conjunction with conventional classroom instruction but a larger sample is needed.

<u>Variables Assessed</u>

Much of the research that evaluates Web-based instruction, and distance education as a whole, lacks a guiding theoretical framework (Saba, 2000; Berge & Mrozowski, 2001). Furthermore, there is no consensus as to what variables are important to examine when evaluating Web-based courses. Determining the evaluation elements becomes more complicated for online courses than for face-to-face instruction as online courses incorporate unique elements such as flexibility, a wide range of corresponding resources and tools, and technological considerations among others. As a result, researchers have assessed a wide range of variables. For the studies included in this analysis, the variables assessed can be grouped into eight major categories:

- Demographics (age, gender, race,)
- Previous computer/Internet experience
- Course design
- Effectiveness of the instructor
- Technical issues
- Level of participation/collaboration
- Recommendation of course to others
- Desire to take additional online courses

Although many of the studies assessed the design of the Web-based course and the demographic characteristics of the participants, fewer evaluated the quality of interaction or collaboration in the course, the effectiveness of the instructor, and the technology itself.

Attrition

It has been widely recognized that the attrition of students is a greater problem for online courses than classroom courses (Phipps & Merisotis, 1999; Terry, 2001). In addition, some research has shown that blended courses should be considered separately from completely online courses when assessing student attrition as blended courses have lower attrition rates (Bonk 2001). However, only 14 (34%) of the studies reported information about attrition. This is unfortunate because of the lost opportunity to better understand the characteristics and motives underlying students' decisions to drop online courses.

Comparison to CBI

When compared to conventional classroom instruction, the learning outcomes from conventional CBI have demonstrated effect sizes significantly above the "no significant difference" threshold (Fletcher, 1990; Kulik, 1994). The original premise stated that if Web-based instruction was employed properly, and used to achieve specific learning objectives, it should lead to effect sizes that are at least comparable to CBI. Of the 15 studies in this analysis that provided sufficient information to calculate effect sizes, eight (53%) of the effect sizes were positive and favored the group that used Web-based instruction, while seven (47%), were negative and favored the group that did not use Web-based instruction. The effect sizes ranged from -.40 to 1.60. The grand mean for all 15 effect sizes was 0.24, and the grand median was 0.095. The standard deviation of 0.58 indicates the great variability of effect sizes across studies.

Because these data did not meet the assumptions of normality and homoscedasticity, non-parametric tests were performed on the mean effect sizes of the current analysis as well as the analyses conducted by Kulik (1994) and Liao (1999) to compare Web-based instruction to CBI. Results of a Kruskal-Wallis Test indicated that there was no significant difference ($p = .47$) in mean effect size across the three sets of analyses. The average effect sizes and their corresponding standard deviations for the studies included in this article and the previous analyses conducted by Kulik and Liao are listed in Table 5.

Table 5
Comparison of Effect Sizes Across Analyses

	Web-Based Instruction	CBI Kulik (1994)	CBI Liao
Average Effect Size	.24	.32	.41
Percentiles	59th	63rd	66th
Average S.D. of Effect Sizes	.58	.39	.87
Number of Studies	15	97	46

These results would seem to suggest that Web-based instruction is “as good” as CBI but, as will be discussed in the following section, this may be a premature conclusion.

Conclusion

On the basis of a limited number of empirical studies, Web-based instruction shows an improvement over conventional classroom instruction. However, it is debatable whether Web-based instruction compares favorably to CBI. On the surface, the overall effect size is smaller, but not statistically significant. This, of course, cannot be interpreted to say that they are equivalent, but rather that there is no detectable difference. This is apparently due to inconsistent and widespread variability in the findings. As the number of studies that report comparative data increase, leading possibly to a more stable central tendency in the effect size, a more reliable assessment of how well Web-based instruction compares to CBI will be possible.

There are numerous reasons why the effectiveness of Web-based instruction may not yet be fully realized. For example, many of the early adapters were apparently faculty from a diversity of fields who were not necessarily trained in the art and science of instructional design. Their comparisons were, in some cases, a first attempt at Web-based instruction compared to a highly practiced classroom rendition of the course. Another restriction may have been response delays not uncommon during peak usage periods on the Internet, in contrast to the immediate responses possible with a stand-alone computer. With packet-based networks, variable delays cause latency problems in the receipt of learning material, particularly with graphic images. Previous research has demonstrated a slight decrement in learning due to inherent delays of transmitting complex graphics over the Internet (Wisher & Curnow, 1999).

One objective of this article was to discuss the various roles that the Web plays in educational courses and the importance of identifying this factor when evaluating courses. Here, we have limited our analysis to those applications involving direct instruction through the Web. As described earlier, there are many other advantages that the Web offers (e.g. access, flexibility, enrollment, and management) that must be factored in when determining the overall value that the Web offers to a learning enterprise.

How large a learning effect, in terms of an effect size, can we expect from the Web? One possibility comes from research on intelligent tutoring systems. These are knowledge-based tutors that generate customized problems, hints, and aids for the individual learner as opposed to ad-hoc, frame-oriented instruction. When compared to classroom instruction, evaluations indicate an effect size of 1.0 and higher (Woolf & Regian, 2000; Wisher, Macpherson. Abramson, Thornton, & Dees, 2001). If these individual learning systems are further complemented by collaborative learning tools and online mentoring, effect sizes on the order of 2 standard deviation units, as suggested by (Bloom, 1984), may someday be possible.

The use of the Web for instruction is at an early stage of development. Until now, there has been a lack of tools for instructional developers to use, but this is beginning to change with the emergence of common international standards (Fletcher & Dodds, 2001). Such standards and specifications, such as the Sharable Content Object Reference Model, allow vendors to develop educational and training content, authoring tools, and repositories that are interoperable. The potential of Web-based instruction for the Army will be furthered as pedagogical practices improve, advances in standards for structured learning content progress, and improvements in bandwidth are made. For now, it appears that Web- based instruction is moving towards the level of effectiveness previously achieved by CBI. As suggested by Fletcher (2001), the Rule of Thirds, reduce the cost of instruction by about one-third, and additionally either reduce the time of instruction by about one-third or increase the effectiveness of instruction by one-third, is likely to apply to Web-based instruction.

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Appendix A
Characteristics of Studies On Web-Based Instructional Effectiveness

Source	Course Evaluated	Educational Level	Extent of Web Use	Sample Size	Comparison Group	Attrition Data	Learning Outcome	Effect Size
Angulo & Bruce (1999)	Psychology, Drama, Philosophy, English Literature, Chemistry	Undergraduate and Graduate	Blend	290	No	No	N/A	N/A
Arvan et al. (1998a)	Spanish	Undergraduate	Blend	118 (78 Web, 40 No Web)	Yes	No	Exam Scores	-0.19
Arvan et al. (1998b)	Statistics	Undergraduate	Blend	304 (203 Web, 101 No Web)	Yes	No	Exam Scores	0.36
Arvan et al. (1998c)	Electrical and Computer Engineering	Undergraduate	Blend	Not Reported	No	No	N/A	N/A
Arvan et al. (1998d)	Chemistry	Undergraduate	All Online	Not Reported	No	No	N/A	N/A
Arvan et al. (1998e)	Calculus	Undergraduate	Blend	Not Reported	Yes	No	N/A	N/A
Arvan et al. (1998f)	Biology	Undergraduate	Blend	Not Reported	No	No	N/A	N/A
Bee & Usip (1998)	Statistics	Undergraduate	Blend	153 (78 Web, 75 No Web)	Yes	No	N/A	N/A
Cooper (2001)	Fundamentals of Computer Applications	Undergraduate	All Online	131 (37 Web, 94 No Web)	Yes	Yes	N/A	N/A
Davies & Mendenhall (1998)	Fitness and Lifestyle Management	Undergraduate	All Online	96 (57 Web, 39 No Web)	Yes	No	Exam Scores	-0.13
Fredericksen et al. (2000a)	Program-wide evaluation of SUNY Learning Network (online instructional program)	Undergraduate	All Online	1,406	No	No	N/A	N/A
Fredericksen et al. (2000b)	Program-wide evaluation of the Internet Academy at Herkimer County Community College	Undergraduate	All Online	Not Reported	Yes	Yes	N/A	N/A
Fredericksen et al. (2000c)	Master's Degree program in Instructional Technology	Graduate	All Online	Not Reported	Yes	Yes	Course Grades	Insufficient Data
Gagne & Shepherd (2001)	Accounting	Graduate	All Online	Not Reported	Yes	No	Exam Scores; Project Grades	Insufficient Data
Green & Gentemann (2001)	English	Undergraduate	All Online	57	No	Yes	Course Grades	Insufficient Data
Johnson (2001)	Political Science	Undergraduate	All Online	89 (40 Web, 49 No Web)	Yes	Yes	Exam Scores	Insufficient Data
Johnson, Aragon, Shaik, & Palma-Rivas (2000)	Human Resources	Graduate	All Online	38 (19 Web, 19 No Web)	Yes	No	Course Projects	-0.12
Jones (1999)	Statistics	Undergraduate	All Online	89 (33 Web, 56 No Web)	Yes	Yes	Exam Scores	Insufficient Data
LaRose, Gregg, & Eastin (1998)	Telecommunications	Undergraduate	Blend	49 (25 Web, 24 No Web)	Yes	No	Exam Scores	Insufficient Data
Leasure, Davis, & Thievon (2000)	Nursing Research	Graduate	All Online	66 (18 Web, 48 No Web)	Yes	No	Exam Scores; Course Grades	0.14; 0.28
Magalhaes & Schiel (1997)	Graphic Mechanics	Undergraduate	All Online	Not Reported	No	No	N/A	N/A
Maki et al. (2000)	Psychology	Undergraduate	Blend	333 (151 Web, 182 No Web)	Yes	Yes	Exam Scores	1.60
Maki & Maki (2002)	Psychology	Undergraduate	Blend	189 (95 Web, 94 No Web)	Yes	Yes	Exam Scores	0.37
McNulty et al. (2000)	Anatomy	Undergraduate	Blend	124	No	No	Course Grades	Insufficient Data
Murphy (2000)	General Soils	Undergraduate	Blend	80 (10 Web, 70 No Web)	Yes	Yes	Exam Scores	0.66
Navarro & Shoemaker (2000)	Economics	Undergraduate	All Online	200 (49 Web, 151 No Web)	Yes	No	Exam Scores	0.59
Phelps & Reynolds (1999)	Meteorology	Undergraduate	All Online	Not Reported	No	No	N/A	N/A
Powers, Davis, & Torrence (1998)	Instructional Technology, Information Technology and Media Literacy, Technologies of Distance Learning	Graduate	All Online	13	No	No	N/A	N/A
Ryan, Carlton, & Ali (1999)	7 Nursing Courses	Graduate	Blend	96	No	No	N/A	N/A
Sandercock & Shaw (1999)	Sports Science	Undergraduate	Blend	80	Yes	No	Assignment Scores; Exam Scores	1.11; 0.095
Schlough & Bhuripanyo (1998)	Task Analysis	Undergraduate	All Online	22	No	No	N/A	N/A
Schulman & Sims (1999)	Organizational Behavior, Personal Finance, Managerial Accounting, Sociological Foundations of Education, Environmental Studies	Undergraduate	All Online	99 (40 Web, 59 No Web)	Yes	No	Exam Scores	0.012
Schutte (1996)	Social Statistics	Undergraduate	All Online	33 (16 Web, 17 No Web)	Yes	Yes	Exam Scores	Insufficient Data

Source	Course Evaluated	Educational Level	Extent of Web Use	Sample Size	Comparison Group	Attrition Data	Learning Outcome	Effect Size
Serban (2000)	Various Courses	Undergraduate	All Online and Blend courses	Not Reported	Yes	Yes	Course Grades	Insufficient Data
Shapley (2000)	Organic Chemistry	Undergraduate	All Online	Not Reported	Yes	No	Exam Scores	Insufficient Data
Shaw & Pieter (2000)	Nutrition	Undergraduate	Blend	46	No	Yes	Course Grades	Insufficient Data
Shuell (2000)	Educational Psychology	Undergraduate	All Online	12	No	Yes	N/A	N/A
Stadtlander (1998)	Motivation	Graduate	All Online	9	No	Yes	Course Grades	Insufficient Data
Summary & Summary (1998)	Economics	Undergraduate	Blend	408	Yes	No	N/A	Insufficient Data
Taylor & Burnkrant (1999)	Computer Science, English, Entomology, Geography, Math, Political Science, Women's Studies, Philosophy	Undergraduate	All Online	520	No	No	N/A	N/A
Thomson & Stringer (1998)	Agricultural Science	Undergraduate	Blend	170	No	No	N/A	N/A
Trier (1999)	Sociology	Undergraduate	All Online	54 (21 Web, 33 No Web)	Yes	Yes	Paper Scores; Exam Scores	0.34; 1.21
Verbrugge (1997)	Computer Operating Systems	Undergraduate	All Online	13	Yes	Yes	Course Grades	Insufficient Data
Wang et al. (2000)	Economics	Undergraduate	All Online	24	No	Yes	Course Grades	Insufficient Data
Waschull (2001)	Psychology	Undergraduate	All Online	41 (18 Web, 23 No Web)	Yes	Yes	Exam Scores	-0.33
Wegner, Holloway, & Garton (1999)	Curriculum Design and Evaluation	Graduate	All Online	31 (14 Web, 17 No Web)	Yes	No	Exam Scores	-0.27
White (1999)	Communication Technology and Change	Undergraduate	All Online	40 (16 Web, 24 No Web)	Yes	No	Course Grades	-0.40