Evaluation of Evidence-Based Practices in Online Learning

A Meta-Analysis and Review of Online Learning Studies

Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies

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Abstract

A systematic search of the research literature from 1996 through July 2008 identified more than a thousand empirical studies of online learning. Analysts screened these studies to find those that (a) contrasted an online to a face-to-face condition, (b) measured student learning outcomes, (c) used a rigorous research design, and (d) provided adequate information to calculate an effect size. As a result of this screening, 50 independent effects were identified that could be subjected to meta-analysis. The meta-analysis found that, on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction.

Executive Summary

Online learning—for students and for teachers—is one of the fastest growing trends in educational uses of technology. The National Center for Education Statistics (2008) estimated that the number of K-12 public school students enrolling in a technology-based distance education course grew by 65 percent in the two years from 2002-03 to 2004-05. On the basis of a more recent district survey, Picciano and Seaman (2009) estimated that more than a million K–12 students took online courses in school year 2007–08.

Online learning overlaps with the broader category of distance learning, which encompasses earlier technologies such as correspondence courses, educational television and videoconferencing. Earlier studies of distance learning concluded that these technologies were not significantly different from regular classroom learning in terms of effectiveness. Policy-makers reasoned that if online instruction is no worse than traditional instruction in terms of student outcomes, then online education initiatives could be justified on the basis of cost efficiency or need to provide access to learners in settings where face-to-face instruction is not feasible.

The question of the relative efficacy of online and face-to-face instruction needs to be revisited, however, in light of today's online learning applications, which can take advantage of a wide range of Web resources, including not only multimedia but also Web-based applications and new collaboration technologies. These forms of online learning are a far cry from the televised broadcasts and videoconferencing that characterized earlier generations of distance education

Policy-makers and practitioners want to know about the effectiveness of Internet-based, interactive online learning approaches and need information about the conditions under which online learning is effective.

The findings presented here are derived from (a) a systematic search for empirical studies of the effectiveness of online learning and (b) a meta-analysis of those studies from which effect sizes that contrasted online and face-to-face instruction could be extracted or estimated. A narrative summary of studies comparing different forms of online learning is also provided.

These activities were undertaken to address four research questions:

1. *How does the effectiveness of online learning compare with that of face-to-face instruction?*
2. *Does supplementing face-to-face instruction with online instruction enhance learning?*
3. *What practices are associated with more effective online learning?*
4. *What conditions influence the effectiveness of online learning?*

This meta-analysis and review of empirical online learning research are part of a broader study of practices in online learning being conducted by SRI International for the Policy and Program Studies Service of the U.S. Department of Education. The goal of the study as a whole is to provide policy-makers, administrators and educators with research-based guidance about how to implement online learning for K–12 education and teacher preparation.

Because the search encompassed the research on career technology, medical and higher education, as well as corporate and military training, it yielded enough studies with older learners to justify a quantitative meta-analysis.

This literature review and meta-analysis differ from recent meta-analyses of distance learning in that they

- Limit the search to studies of Web-based instruction (i.e., eliminating studies of video- and audio-based telecourses or stand-alone, computer-based instruction);

- Include only studies with random-assignment or controlled quasi-experimental designs; and

- Examine effects only for objective measures of student learning (e.g., discarding effects for student or teacher perceptions of learning or course quality, student affect, etc.).

This analysis and review distinguish between instruction that is offered entirely online and instruction that combines online and face-to-face elements. The first of the alternatives to classroom-based instruction, entirely online instruction, is attractive on the basis of cost and convenience as long as it is as effective as classroom instruction. The second alternative, which the online learning field generally refers to as blended or hybrid learning, needs to be *more* effective than conventional face-to-face instruction to justify the additional time and costs it entails. Because the evaluation criteria for the two types of learning differ, this meta-analysis presents separate estimates of mean effect size for the two subsets of studies.

Literature Search

The computerized searches of online databases and citations in prior meta-analyses of distance learning as well as a manual search of the last three years of key journals returned 1,132 abstracts. In two stages of screening of the abstracts and full texts of the articles, 176 online learning research studies published between 1996 and 2008 were identified that used an experimental or quasi-experimental design and objectively measured student learning outcomes.

Of these 176 studies, 99 had at least one contrast between an included online or blended learning condition and face-to-face (offline) instruction that potentially could be used in the quantitative meta-analysis. Just nine of these 99 involved K–12 learners. The 77 studies without a face-to-face condition compared different variations of online learning (without a face-to-face control condition) and were set aside for narrative synthesis.

Meta-Analysis

Meta-analysis is a technique for combining the results of multiple experiments or quasi-experiments to obtain a composite estimate of the size of the effect. The result of each experiment is expressed as an *effect size*, which is the difference between the mean for the treatment group and the mean for the control group, divided by the pooled standard deviation. Of the 99 studies comparing online and face-to-face conditions, 45 provided sufficient data to compute or estimate 50 independent effect sizes (some studies included more than one effect).

Most of the articles containing the 50 effects in the meta-analysis were published in 2004 or more recently. The split between studies of purely online learning and those contrasting blended online/face-to-face conditions against face-to-face instruction was fairly even, with 27 effects in the first category and 23 in the second. The 50 estimated effect sizes included seven contrasts from five studies conducted with K–12 learners.

The types of learners in the
remaining studies were about evenly split between college or community college students and graduate students or adults receiving professional training. All but two of the studies involved formal instruction. The most common subject matter was medicine or health care. Other content types were computer science, teacher education, mathematics, languages, science, social science, and business. Among the 48 contrasts from studies that indicated the time period over which instruction occurred, 19 involved instructional time frames of less than a month, and the remainder involved longer periods. In terms of instructional features, the online learning conditions in these studies were less likely to be instructor-directed (8 contrasts) than they were to be student-directed, independent learning (17 contrasts) or interactive and collaborative in nature (22 contrasts).

Effect sizes were computed or estimated for this final set of 50 contrasts. Among the 50 individual study effects, 11 were significantly positive, favoring the online or blended learning condition. Only three contrasts found a statistically significant effect favoring the traditional face-to-face condition.[1]

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[1] When a $\alpha < .05$ level of significance is used for contrasts, one would expect approximately 1 in 20 contrasts to show a significant difference by chance. For 50 contrasts, then, one would expect 2 or 3 significant differences by chance. The finding of 3 significant contrasts associated with face-to-face instruction is within the range one would expect by chance; the 11 contrasts associated with online or hybrid instruction exceeds what one would expect by chance.

Narrative Synthesis

In addition to the meta-analysis comparing online learning conditions with face-to-face instruction, analysts reviewed and summarized experimental and quasi-experimental studies contrasting different versions of online learning. Some of these studies contrasted purely online learning conditions with classes that combined online and face-to-face interactions. Others explored online learning with and without elements such as video, online quizzes, assigned groups, or guidance for online activities.

Key Findings

The meta-analysis of 50 study effects found that[2]

- *Students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction.* Learning outcomes for students who engaged in online learning exceeded those of students receiving face-to-face instruction, with an average effect size of +0.20 favoring online conditions.[3] The mean difference between online and face-to-face conditions across the 50 contrasts is statistically significant at the $p < .001$ level.[4]

- Interpretations of the advantage of online learning over face-to-face instruction should take into consideration the fact that online and face-to-face conditions generally differ on multiple dimensions, including the amount of time that learners spend on task. *The advantages observed for online learning conditions therefore may be the product of learners spending more time on task during online instruction than face-to-face instruction.*

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[2] The meta-analysis was run also with just the 43 studies with only the older learners. Results were very similar to those for the meta-analysis including all 50 contrasts.

[3] The + sign indicates that the outcome for the treatment condition was larger than that for the control condition. A – sign before an effect estimate would indicate that students in the control condition had stronger outcomes than those in the treatment condition. Cohen (1992) suggests that effect sizes of .20 can be considered "small," those of approximately .50 "medium," and those of .80 or greater "large."

[4] The *p*-value represents the likelihood that an effect of this size or larger will be found by chance if the two populations under comparison do not differ. A *p*-value of less than .05 indicates that there is less than 1 chance in 20 that a difference of the observed size would be found for samples drawn from populations that do not differ.

- *Effect sizes were larger for studies in which the online instruction was **collaborative** or **instructor-directed** rather than studies where online learners worked independently.* The type of learning experience moderated the size of the online learning effect (Q = 6.19, p < .05). The mean effect sizes for collaborative instruction (+0.25) and for instructor-directed instruction (+0.39) were significantly positive whereas the mean effect size for independent learning (+0.05) was not.

- *Many of the variations in the way in which different studies implemented online learning did not affect student learning outcomes significantly.* Analysts examined 13 online learning practices as potential sources of variation in the effectiveness of online learning compared with face-to-face instruction. Of those variables, the two mentioned above (i.e., the use of a blended rather than a purely online approach and instructor-directed or collaborative rather than independent, self-directed instruction) were the only statistically significant influences on effectiveness.

- *The effectiveness of online learning approaches appears quite broad across different learner types.* Online learning appeared to be an effective option for both undergraduates (mean effect of +0.30, *p* < .001) and for graduate students and professionals (+0.10, *p* < .05) in a wide range of academic and professional studies.

- *The effectiveness of online learning approaches appears quite broad across different content.* No significant differences in effectiveness were found that related to the subject of instruction (i.e., the content being learned).

- *Effect sizes were larger for studies in which the online and face-to-face conditions varied in terms of curriculum materials and aspects of instructional approach in addition to the medium of instruction.* Studies in which analysts judged the curriculum and instruction to be identical or almost identical in online and face-to-face conditions had smaller effects than those studies where the two conditions varied in terms of multiple aspects of instruction (+0.13 compared with +0.40, respectively).

The narrative review of experimental and quasi-experimental studies contrasting different online learning practices suggest the following:

- *Blended and purely online learning conditions implemented within a single study generally result in similar student learning outcomes.* When a study contrasts blended and purely online conditions, student learning is usually comparable across the two conditions.

- *Frequent online quizzes do not appear to influence the amount that students learn in online classes.* The research does not support the use of a commonly recommended online learning practice – the practice of providing online quizzes. Frequent online quizzes do not seem to be more effective than assigning homework.

- *Online learning can be enhanced by giving learners control of their interactions with media and bu prompting learner reflection.* Studies indicate that manipulations that trigger learner activity or learner reflection and self-monitoring of understanding are effective when students pursue online learning as individuals.

- *Providing instruction en mass to large groups of students appears less successful than providing instruction that requires each indivdiual learner to operate on the material independently.*

- *Extensive use of video does not appear to enhance the amount that students learn in online classes.* Inclusion of more extensive video is not as effective as other learning strategies, such as frequent assignments or homework.