Does eLearning Work?
What the Scientific Research Says!

Research Compiled by Will Thalheimer, PhD

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His clients have included giant multinationals, elearning companies, government agencies, and institutions of higher learning. Short list: Naval Special Warfare Center (Navy Seals), Liberty Mutual, McKinsey, Allen Interactions, Walgreens, NexLearn, Society of Actuaries, Practising Law Institute, Monitor Group, Pfizer, ADP, Questionmark, Midi Compliance Solutions, The eLearning Guild, Novartis, HCSC BlueCross BlueShield, SIOP, Defense Intelligence Agency (DIA), Johnsonville Sausage, Intermountain Health, Tufts University, MIT, Microsoft, Genentech, Bloomberg. His research and writings have led the field in providing practical research-based recommendations through his online publications (www.work-learning.com/catalog.html), published articles, his industry-leading blog (www.willatworklearning.com) and Twitter (@WillWorkLearn).

Dr. Thalheimer speaks regularly at national and international conferences. His conference presentations always receive numerous evaluation-sheet comments like the following: "This was one of the best presentations I attended—solid information delivered in a style that helped me learn."

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Executive Summary

This research effort began with the questions, “Does eLearning Work?” and “What does the scientific research tell us about elearning effectiveness, particularly as it compares with classroom instruction?” Obviously, in real-world applications, elearning is thought to work, as millions of people use elearning every day. On the other hand, elearning has had a reputation for being boring and ineffective at the same time it is wildly hyped by vendors and elearning evangelists.

By looking at the scientific research on elearning, we can examine elearning effectiveness when it is rigorously studied and when skeptical scientists examine it with well-designed research studies that work to eliminate biases, misperceptions, and overzealous commercial enthusiasms.

This research report includes four sections:

1. Meta-Analyses Comparing eLearning to Traditional Classroom Instruction
2. Examples of Single Research Studies Comparing eLearning to Classroom Instruction
3. Examples of Other eLearning-Relevant Research Studies
4. Meta-Analyses of Other Technologies Relevant to eLearning

Including all the research articles covered in the meta-analyses examined here, this report reflects the findings from thousands of scientific studies. Scientific articles were chosen for inclusion based on their methodological rigor, their relevance to practical elearning, and with the goal of comprising a representative sample of research studies.

First Section

In the first section of the report, five meta-analyses were summarized, comparing elearning and learning technologies in general to traditional classroom practice. Overall, these meta-analyses found that elearning tends to outperform classroom instruction, and blended learning (using both online learning and classroom instruction) creates the largest benefits.

Looking more deeply at the results, there is clear evidence to suggest that it is not the elearning modality that improves learning, but, instead, it is the learning methods typically used in elearning—and used more often than in classroom instruction—that create elearning’s benefits. These learning methods include such factors as providing learners with realistic practice, spaced repetitions, contextually-meaningful scenarios, and feedback.

The review of these meta-analyses also points out that typical elearning designs may not be as effective as they might be. By utilizing research-based best practices, standard elearning programs can be made much more effective.

Finally, the first section highlights that classroom instruction can also utilize these proven research-based learning methods to improve learning outcomes.

Second Section

In the second section of the report, six research articles were examined—each comparing elearning to traditional classroom instruction. These articles highlight the richness of elearning, examining such varied learning methods as the flipped classroom, online role playing, supplemental instruction for difficult topics, facilitated elearning, mobile learning, and learning-based behavior change.

We also see in these studies that elearning produces varied results—not always better than classroom instruction—reinforcing the findings of the meta-analyses from the first section, which showed a wide variability in results despite evidence showing elearning's overall advantages.

Third Section

In the third section, we looked at other research—research that does NOT look at elearning in comparison to traditional instruction, but, rather, looks at elearning to help determine the value of various elearning design elements. In the six studies reviewed, we can again see the depth and variety that elearning may utilize. The targeted topics included how to engage in forensic interviews, solving linear algebra problems, making sense of cerebral hemorrhages, how to pull a person to safety, understanding the Doppler Effect, and identifying plants and their attributes. As evidenced in the research cited, elearning is not relegated to simple learning materials or trivial tasks.

Fourth Section

In the final section of this report we looked at other meta-analyses—those examining topics relevant to elearning. In this section, we see the variety of learning methods on which researchers focus in elearning, including simulations, simulation games, feedback, animations, digital games, learner control, computer-mediated language learning, interactivity, and elearning acceptance.

Overall Conclusions

1. When learning methods are held constant between elearning and classroom instruction, both produce equal results.
2. When no special efforts are made to hold learning methods constant, elearning tends to outperform traditional classroom instruction.
3. A great deal of variability is evident in the research. eLearning often produces better results than classroom instruction, often produces worse results, often similar results.
4. What matters, in terms of learning effectiveness, is NOT the learning modality (elearning vs. classroom); it's the learning methods that matter, including such factors as realistic practice, spaced repetitions, real-world contexts, and feedback.
5. Blended learning (using elearning with classroom instruction) tends to outperform classroom learning by relatively large magnitudes, probably because the elearning used in blended learning often uses more effective learning methods.

Introduction

eLearning is ubiquitous in workplace learning and higher education. The trade group Association for Talent Development reports that technology-enabled learning in the workforce has grown over 150% from 2000 through 2015, being used in 16% of training situations in 2000 and 41% in 2015 (Ho, 2015; Sugrue & Rivera, 2005). The United States National Center for Education Statistics reported a 105% rise in the number of college students taking online courses between 2004 and 2012—from 15.6% to 32%. eLearning is clearly on the rise (NCES, 2017).

While elearning predates the Internet—with such earlier technologies as stand-alone computer-based training and interactive video—it has exploded in power, reach, and relevance since the Internet revolution. In the early days of elearning, it too often comprised poorly-designed interactions where simulated page-turning was the most common mode of learning. eLearning deficits were obvious. Learners were bored, disengaged, and left unable to remember even the basics of what they'd seen.

But is this stereotype of poorly-designed elearning still relevant today? In this paper, I'll attempt to answer that question by looking at the scientific research to determine if elearning can be effective if well designed and delivered. By looking at research from scientific refereed journals, we can look beyond marketing claims by vendors and overzealous elearning evangelists. We can determine whether elearning is an approach worth utilizing. We can decide whether elearning works.

To explore this question, we'll look first at research reviews and meta-analyses combining wisdom from many scientific studies. After this synopsis, we'll look to rigorously-designed experiments on elearning—to learn what we might from specific examples of elearning. Finally, we'll review other meta-analysis that look at technologies relevant to elearning.

By examining these different sources of data, we will gain a broad and deeply nuanced perspective on whether elearning is likely to be effective—and on what design elements maximize its effectiveness.

In today's context, elearning involves a constellation of digital technologies that enable learners to engage in learning activities via various modalities—primarily on computers, tablets, and smartphones. eLearning can be used in conjunction with classroom instruction—a practice commonly referred to as "blended learning."

While elearning was once delivered almost entirely via computer in relatively long learning sessions of 30 minutes or more, today's elearning can be directed to a number of different devices and can include brief "microlearning" segments—sometimes 5 minutes or less. Where elearning was once only about information dissemination, more and more it can involve meaningful tasks, socially-supported learning, and facilitation of on-the-job learning.

SECTION 1—Meta-Analyses Comparing eLearning to Traditional Classroom Instruction

Looking at one research study can provide useful insights, but skepticism is required when examining a single experimental study. For example, one experiment could produce results by chance or could be unrepresentative of what's normally expected. For this reason, researchers compile wisdom from multiple studies, either reviewing a wide array of research articles or utilizing statistical meta-analytic techniques to make sense of multiple experimental studies. In this section, we'll look specifically at meta-analyses—compilations of many other scientific studies that use statistical techniques to make sense of the data.

Tamim and Colleagues 2011—Second-Order Meta-Analysis

In 2011, Tamim, Bernard, Borokhovski, Abrami, and Schmid did a second-order meta-analysis (a meta-analysis of meta-analyses) and found 25 meta-analyses focused on the potential of learning technologies in educational settings covering a range of topics, including engineering, language learning, mathematics, science, and health. These meta-analyses examined 1,055 research studies and more than 100,000 learners and found that, in general, learners who were provided with learning technologies learned more than learners who did not utilize learning technologies.[1] Tamim and colleagues examined meta-analyses beginning in 1985, so many of the technologies examined predated Internet-enabled learning.

Sitzmann and Colleagues 2006—Meta-Analysis

In 2006, Sitzmann, Kraiger, Stewart, and Wisher examined 96 scientific studies focusing on adult learners. They utilized a rigorous methodology to ensure they were comparing Web-based instruction to classroom training in a way that didn't confuse learning methods (e.g., lecture, testing, reflection) with learning media (online vs. classroom).

What Sitzmann and her colleagues found was the following:

- eLearning produced slightly better learning results than classroom instruction for declarative knowledge—that is, knowledge of facts and principles.[2]

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[1] They found Cohen's *d* effect-size improvements averaging *d* = .35, a significant finding, and one that, when compared to other memory-research findings, produced results at roughly the 34th percentile of findings (with a partial eta squared, that is, η_p^2, of 0.34).

[2] The Cohen's *d* effect size reported of 0.15 indicates a result at about the 9th percentile of all memory-research studies. There are some complicating factors regarding this finding. First, when learning methods were held the same between online and classroom, no difference was found. When learning methods were allowed to differ, elearning outperformed classroom instruction by 11% (Cohen's *d* = .29, at about the 19th percentile). Second, when experimental methods (e.g., random assignments) were used, classroom instruction outperformed elearning (Cohen's *d* = -0.26, at about the 17th percentile); compared with the much larger cohort of studies where quasi-experimental methods were used, when elearning tended to slightly outperform classroom instruction (probably

- eLearning and classroom learning were equally effective for procedural knowledge—that is, knowledge on how to perform a skill, task, or action.

- Learners were equally satisfied with both elearning and classroom instruction.

- Blended learning (using both classroom and online learning) outperformed classroom instruction on declarative knowledge by 13%[3] and procedural knowledge by 20%.[4] As the authors pointed out, an earlier meta-analysis of distance learning research found similar benefits to blended learning (Zhao, Lei, Lai, & Tan, 2005).

- Learners were 6% less satisfied with blended learning than they were with classroom learning; but, as the researchers point out, this might have to do with increasing time demands in using blended learning over classroom learning alone.[5]

Overall, this meta-analysis found that elearning was at least as effective as classroom learning (perhaps even better for declarative knowledge), and adding online components to classroom instruction—in other words, using blended learning—may produce significant additional advantages.

Means and Colleagues 2013—Meta-Analysis

Means, Toyama, Murphy, Bakia (2013) reanalyzed data from an earlier meta-analysis they had conducted in 2009 while working for The Center for Technology in Learning at the U.S. Department of Education (Means, Toyama, Murphy, Bakia, & Jones, 2009). Their meta-analysis was exceptionally rigorous, utilizing only experimental designs and quasi-experimental designs that utilized statistical controls ensuring that experimental groups were comparable. About half of their studies involved students in college or younger, while half were in workplace learning situations or graduate school. The most common content areas provided to learners were medicine and health care, but other topics included "*computer science, teacher education, social science, mathematics, languages, science, and business*." They found the following:

- *"The overall finding of the meta-analysis is that online learning (the combination of studies of purely online and of blended learning) on average produces stronger student learning outcomes than learning solely through face-to-face instruction."* (p. 29).[6]

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because of logistical difficulties inherent in assigning learners to experimental groups in typical adult-learning situations).

[3] Cohen's *d* = .34, at about the 24th percentile.

[4] Cohen's *d* = .52, at about the 40th percentile.

[5] The absolute value of Cohen's *d* effect size was 0.15, at about the 8th percentile.

[6] The average Hedges' *g+* effect size was .20, producing a comparative result at about the 14th percentile of memory studies, a well-below-average effect.

- eLearning-only situations produced an equal amount of learning compared with classroom-only situations.[7]
- Blended learning (a combination of both classroom and online learning) produced better results than classroom-only instruction.[8]

Overall, this meta-analysis found that elearning was at least as effective as classroom learning—and blended learning may produce significant additional advantages. Where the Sitzmann and colleagues' meta-analysis showed a small advantage for elearning overall compared to classroom instruction, this meta-analysis showed that elearning produced results that equaled classroom instruction.

Schmid and Colleagues 2014—Meta-Analysis

In an exhaustive meta-analysis of multiple learning technologies used in postsecondary education—but excluding Internet-enabled elearning—Schmid and his colleagues found a small but reliable advantage for learning contexts where technologies were used.[9] To reiterate, this meta-analysis looked largely at how non-Internet computer-assisted instruction compared with classroom instruction and found an advantage for computer-assisted instruction.

Bernard and Colleagues 2014—Meta-Analysis on Blended Learning

In a meta-analysis coordinated with the Schmid et al. (2014) meta-analysis, Bernard and colleagues (2014) looked specifically at blended learning in higher education, including both undergraduate and graduate education. For the purpose of their meta-analysis, blended learning was operationalized as *"instructional conditions in which at least 50% of total course time is face-to-face classroom instruction and students working online outside of the classroom spend the remainder of time, up to the additional 50%, online."* Overall, the meta-analysis revealed that blended learning outperformed classroom instruction.[10] The researchers specifically did not look to compare the same learning methods utilized in both blended and classroom learning. Their findings therefore may reflect the benefits of different learning methods, not the advantage of blended learning per se. Of course, if blended-learning instruction tends to use more effective learning methods than those used in classroom training, then it will produce better results.

[7] The effect size was a non-significant .05, slightly favoring elearning-only over classroom-only.
[8] The effect size was .35, compared to other memory studies at the 25th percentile. A later meta-analysis focusing on blended learning found a similar advantage for blended learning over classroom instruction, with an effect size of .33 (Bernard, Borokhovski, Schmid, Tamim, Abrami, & Philip, 2014), comparable to the 23rd percentile of research studies on memory.
[9] With an effect size of .27 overall for achievement and .20 for learner satisfaction.
[10] With a small-to-moderate effect size of .33, producing a comparative result at the 23rd percentile.

Summary of Meta-Analyses—eLearning Outperforms the Classroom

Overall, the meta-analyses found that elearning tends to outperform classroom instruction, and blended learning (using both online learning and classroom instruction) creates the largest benefits.[11]

When learning methods are held constant—for example, if learners get a lecture in a classroom compared with getting a lecture delivered in an online video—then elearning will create roughly the same benefits as classroom instruction. Clark's (1983) admonition is still true—it's not the media, it's the learning methods that matter! Clark's (2012) critique of elearning meta-analyses is prescient—most do not hold learning methods constant, so we can't conclude that elearning is better independent of the learning methods used.

The bottom line is that elearning in the real world tends to outperform classroom instruction because elearning programs tend to utilize more effective learning methods than classroom instruction, which still tends to rely on relatively ineffective lectures as the prime instructional method. Indeed, the finding that blended learning outperforms classroom instruction alone is a testament to this truth. When learning designers add technology-enabled capabilities, they tend to add learning methods that are different from—and more effective than—those typically used in the classroom.

What Learning Methods Are Most Effective?

In general, providing learners with realistic decision making and authentic tasks, providing feedback on these activities, and spreading repetitions of these activities over time produces large benefits. These general findings are well established, communicated in research-to-practice reports (Thalheimer, 2012), popular mainstream books written by researchers (Brown, Roediger, and McDaniel, 2014; Hattie, 2012), books written by thought leaders in the workplace learning field (Dirksen, 2015), and research reviews in top-tier scientific journals (Salas, Tannenbaum, Kraiger, & Smith-Jentsch, 2012). To be clear, the meta-analytic results, when they show benefits to elearning and blended learning, are not due to the technology; the improved effectiveness is due to the learning methods utilized via the technology.

Of course, classroom instruction can utilize these beneficial learning methods too, but it usually doesn't. And it should be noted, elearning can fail to utilize the most effective learning methods, which, unfortunately, happens too often (Allen, Dirksen, Quinn, & Thalheimer, 2014).

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[11] Compared with the Morris-Fritz memory-research findings, these meta-analyses find elearning benefits in the bottom quintile (up to the 20th percentile), whereas blended learning benefits tend to be in the next quintile (between the 20th and 40th percentiles).

eLearning Can Be Made Even More Effective

Overall, the research shows that elearning and blended learning tend to outperform classroom instruction, but the research hints at elearning's missed opportunities as well. We've seen that the advantages of elearning tend to be small to moderate. Why aren't elearning improvements more pronounced? The most likely cause is that many elearning programs don't fully utilize research-based learning factors in their designs. eLearning may outperform classroom instruction, but it may suffer from the same problems—a lack of proven learning methods.

To examine this possibility, let's take one learning factor proven to produce robust learning effects—retrieval practice. Retrieval practice prompts learners to retrieve information from memory, typically by asking learners questions or engaging them in decision making. Most often, prompting learners to retrieve information from memory produces strong memory gains, helping them remember what they've learned. Several recent research reviews provide testaments to the power of retrieval practice (Roediger & Butler, 2011; Roediger & Karpicke, 2006; Bjork, 1988).

If elearning or classroom instruction utilize retrieval practice in ways that are fully effective, they should create improved learning. Let's look at elearning specifically and compare its results to the results from typical retrieval-practice interventions. The bottom line is this: overall, the elearning meta-analyses produced weaker results than the retrieval-practice results.[12]

Take a look at the following table comparing elearning and blended learning results to typical retrieval-practice results.

[12] In a 2014 meta-analysis on retrieval practice, Rowland found that overall retrieval practice produced moderate effect size improvements, with an effect size of .50, which would place it at about the 38th percentile of typical memory-research findings. When retrieval practice was induced by stronger methods than multiple-choice questions, its effects were even stronger. For cued-recall the effect size benefits were .72 (54th percentile); free recall produced an effect size of .82 (62nd percentile). How does this compare to our elearning findings? Using the Morris-Fritz (2013) research compilation of typical memory-research findings, we can make such a comparison.

Percentile of Meta-Analytic Findings eLearning and Blended Learning Compared with Retrieval Practice	
eLearning vs. Classroom	12th percentile[13]
Blended Learning vs. Classroom	24th percentile[14]
Retrieval Practice vs. Restudy (Overall)	38th percentile
Retrieval Practice vs. Restudy (Cued Recall)	54th percentile
Retrieval Practice vs. Restudy (Free Recall)	62nd percentile

As you can see, elearning meta-analyses (the first two rows in the table above) find lower levels of learning benefits compared with retrieval practice alone (the bottom three rows in the table)—providing evidence that many elearning programs are not as effective as they might be if they utilized research-validated learning factors like retrieval practice, spaced repetitions, realistic decision making, and feedback. And note that, in this comparison, we are comparing only one proven research-based learning factor—that is, retrieval practice—with the results of typical elearning programs. Using several research-based learning factors at once would certainly produce even better results!

To summarize, elearning produces advantages over classroom instruction because it tends to utilize more effective learning methods. However, at the same time, elearning itself can produce better outcomes if it too utilized more research-recommended learning methods.

[13] The percentile for elearning benefits compared with classroom benefits was estimated using the Morris & Fritz (2013) memory research findings to interpret the statistically-significant findings of Sitzmann et al. (2006) and Means et al. (2013).
[14] The percentile for blended learning was estimated using the Morris & Fritz (2013) findings to interpret the findings of Means et al. (2013) and Bernard et al. (2014).

SECTION 2—eLearning Research Examples—eLearning Compared

Section 1 looked at meta-analytic research reviews and concluded that elearning typically outperforms classroom instruction. In this section, individual research studies will be used to illustrate the types and varieties of elearning that have been studied in the scientific literature.

The research cited here will sample from the hundreds of scientific studies on elearning that have been conducted within the past 15 years. Studies were chosen because of their experimental rigor and their relevance to real-world learning. There was no attempt to select a representative sample of elearning types. Rather, these studies are offered to provide a ground-level view of elearning research—one not available from meta-analyses given that they compile many studies. Six studies are offered in no particular order—each compare elearning to other learning media (or to no instruction at all).

In this section, the focus will be on studies that compared elearning to other learning media. In the section after this one, the focus will be on elearning studies where researchers wanted to determine which learning method was most effective when one elearning program was compared with another.

The Flipped Classroom Compared to other Modalities
Thai, De Wever, Valcke (2017)

The "flipped classroom" is a form of blended learning (elearning and classroom learning) where learners view lectures online and then engage in other learning-related activities in the classroom. In this study, a flipped-classroom condition was compared with a classroom-only condition, an online-only condition, and a reverse flipped-classroom condition (where learners got lectures in the classroom and engaged in guided-question discussions online). To ensure comparisons between the different conditions were fair, the researchers provided only three learning modalities (1) lectures, (2) guiding questions, and (3) a textbook, and varied where the lectures and guiding questions were utilized (online or in the classroom). The guiding questions asked the learners to write short essays in response to questions related to the content. Learners received feedback during these activities and were able to incorporate improvements into their essays. The results on later tests of learning revealed that the flipped classroom outperformed elearning-only instruction[15] and the classroom-only instruction,[16] but only marginally outperformed the other blended-learning condition.[17]

[15] Cohen's *d* = 1.58, coming in at the 88th percentile.
[16] Cohen's *d* = 1.01, coming in at the 70th percentile.
[17] Cohen's *d* = .71, but only a marginal p-value (p = 0.088), indicating that there may not have been any difference between the flipped classroom and the reverse flipped classroom.

Role Playing: Online vs. Face-to-Face

Buchanan & Palmer (2017)

Role-playing activities used in learning have a long and robust history. Their benefits include prompting learners to be active in learning and enabling both emotional and intellectual engagement. For this reason, role playing is most often conducted in face-to-face settings. In this study, researchers wanted to find out whether role playing might work if utilized in an online environment. They specifically used a role-playing intervention that supports the teaching of history, called *Reacting to the Past*, which was developed by a Columbia University researcher/educator, and has been scientifically validated to outperform lecture-based classroom instruction. The findings were mixed. While most of the learning assessments found no difference between online and classroom role playing, there was one comparison that created a learning advantage for the face-to-face role playing. Also, the classroom role playing was rated higher by learners. As the researchers point out, the minor benefits seen from classroom role playing might disappear as learners get more comfortable with the technology and as learning-design tweaks are made based on feedback from additional teaching attempts.

Supplemental Instruction: Online vs. Face-to-Face

Hizer, Schultz, and Bray (2017)

Supplemental Instruction is a research-validated model used in universities, *"designed to help students in historically difficult classes master course content while they develop and integrate learning and study strategies using a peer-led discussion format."* Typically used in science, math, and technology courses, supplemental instruction has been shown to support students in being successful and persevering through difficult subject matter. Traditionally, supplemental instruction is conducted in face-to-face sessions. However, in this study, Hizer, Schultz, and Bray (2017) compared a traditional face-to-face supplemental-instruction program to an online supplemental-instruction program that used an online collaborative system that enabled whiteboard activities, text and audio chats, posting of classroom lectures, sharing of files, and collaborative work on documents.

Learners who signed up for supplemental instruction were randomly assigned to either the online or traditional method. Courses included Introduction to Cellular and Molecular Biology, Experimental Design and Statistical Analysis, Genetics, and Molecular and Cellular Biology. The results showed that the online supplemental instruction was just as effective as the traditional method and was rated as highly by learners. On the other hand, the drop-out rates were roughly three times as high for the online version—although there was some suggestion that, because this was a first-time effort, they might be able to lower that rate in subsequent efforts. For example, initially the online peer facilitators did not show their webcam images, but later added these as students asked to see those images.

Learning the Law as Undergraduates

Shelley, Swartz, Cole (2007, 2008)

In two separate research studies, these authors looked at undergraduate students learning the law. Overall, they found mixed results. In the 2008 study, they found learning results were better in the elearning condition. They also found that learners rated the elearning with the same level of satisfaction as they rated the classroom instruction, though they did rate the instructors and course organization less highly. In the 2007 study, they found no difference in learning or satisfaction between elearning and classroom instruction. These results should be considered with some caution as learners were not randomly assigned to conditions and the elearning technology back in the early-to-mid 2000s was not as well designed as it is now. Still, the results are interesting in that the same content was tested twice and different results were found.

Intrinsic Motivation in Blended Learning: Mobile App vs. Textbook

Jeno, Grytnes, Vandvik (2017)

In biology, an important task is to be able to identify species. In this study learners were given a classroom-based introduction to species identification and then were given the task of identifying different types of sedges. They were randomly assigned to two supports: either a mobile app specifically designed to support species identification or a textbook that supported a similar goal. The results showed that learners learned more, rated their competence more highly, and reported being more intrinsically motivated when they were in the mobile-app condition.[18]

Preventing Obesity Through eLearning

Nikolaou, Hankey, & Lean (2015)

Obesity is a debilitating issue in much of the developing world. In this study, researchers were interested in whether elearning might be able to prevent obesity in healthy young adults (not necessarily people already obese). They compared a control group that got no intervention with two elearning programs, with all participants randomly assigned to groups. One of the elearning programs simply provided learners with rational arguments about why and how to lose weight. The second program took an indirect approach, aiming *"to prevent obesity covertly, by raising discussion around social and political movements which are associated with more, or less, healthful diets and lifestyles."* People in the elearning groups logged into their respective programs, on average, about six times over 19 weeks. At the end of the nine-month study, the control group had gained 2 kilograms, while both elearning groups had lost about 1 kilogram.

[18] The Cohen's *d* effect size for learning was .54 (40th percentile); for self-perceptions of competence *d* = .82 (62nd percentile); and, for intrinsic motivation, *d* = 1.73 (91st percentile).

Summary of Research Validating the Effectiveness of eLearning

As was evidenced in the meta-analyses put forward in Section 1, there is a ton of research comparing elearning to classroom instruction. The six studies reviewed just above show the wide variety of comparisons that are made. We examined one study that compared a blended-learning flipped classroom to a classroom-only condition, an online-only condition, and a reverse flipped-classroom condition. We looked at a study that compared online role playing with classroom role playing, another that looked at supplemental instruction sessions conducted online or face-to-face, a study that compared facilitated elearning to classroom instruction, another study that compared the benefits of mobile learning to using a textbook, and, finally, we looked at whether two widely different approaches to elearning could prevent obesity.

We saw that varied results can occur: elearning can outperform the classroom, it can perform worse, or it can perform about the same. These studies reinforce the findings we saw in the meta-analyses—elearning can be more effective, but it doesn't have to be. What makes elearning effective is its design elements—that is, the learning methods utilized.

Where this section focused on research comparing elearning to other types of instruction, the next section will look at comparisons of different learning methods used in elearning.

SECTION 3—Learning Methods Evaluated Within eLearning

This section includes studies where different learning methods were compared using some form of online learning. These examples demonstrate the depth and breadth of elearning content and design.

Forensic Interview Training—Largely Through eLearning

Benson & Powell (2015)

Interviewing children in legal investigations is a very difficult task. In this study, researchers first looked at the available evidence on traditional classroom instruction and found that, while training produced improvements in performance, those improvements were not sustained over time.

In this research, researchers evaluated an elearning intervention for use with professionals, including detectives, police officers, and child-protection workers. The training involved multiple learning methods within an elearning framework (including such methods as *"interactive exercises, short film clips, exemplars of best practice, narrated presentations, virtual simulations, self-initiated practices, and quizzes with immediate feedback and explanations of the answers."*). A pretest-to-posttest design was utilized—and it should be noted that over 50% of the trainees had already been certified as specialist child interviewers through previous organizational training, so training benefits were not the result of novices being clueless on the pretest. Moreover, the "pretest" was not a quiz but a simulated interview.

The research results showed significant increases in the number of open-ended questions asked and significant decreases in overly-specific questions and leading questions—all desired results.[19] These improvements were maintained or even improved from the after-training assessment to a later assessment given three to six months later. Because the training involved so many learning methods, though, it was not possible to determine the ultimate causes for the learning improvements and the sustained performance, but the researchers conjectured that elearning's capability to enable learning to be delivered over time and provide deliberate practice and feedback probably created the strong success reported.

Computer-Based Feedback for Mathematics Problem Solving

Corbalan, Paas, & Cuypers (2010)

Researchers were interested in determining what type of feedback was most valuable for learners learning to solve math problems. They provided learners with linear algebra

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[19] Partial eta-squared effect sizes revealed that open-ended questions produced results—in comparison to typical memory results—at about the 77th percentile ($\eta_p^2 = 0.44$), while a focus on overly-specific questions produced improvements at about the 70th percentile ($\eta_p^2 = 0.36$).

problems and then either of two computer-based feedback types: (1) feedback after learners completed each phase of problem solving or (2) feedback after a full solution had been constructed. They found no comparative benefits when learners had to solve similar problems—both feedback strategies worked equally well. But, when learners were asked to transfer their new knowledge to problems constructed differently, previous experience getting step-by-step feedback produced much better learning results than feedback given after a final solution had been constructed.[20] Learners also preferred step-by-step feedback, especially for difficult problem types.

Does Personalizing Help with Emotionally-Aversive Content
Kühl & Zander (2017)

Research generally finds that a conversational writing style—especially one that uses personal pronouns such as "you" and "your"—creates better learning outcomes.

In this experiment, the researchers wondered if that would hold true even when the content was potentially distressing emotionally. In an elearning program, they presented learners with information about cerebral hemorrhages—using one of two conditions. The text was either personalized with personal pronouns or it was not. In two experiments, they found that, regardless of condition, learners were able to remember the content at about the same proficiency. However, when they were asked to use their new knowledge to make decisions on novel problems, the learners who got the personalized messages did worse. Thus, the general principle regarding personalizing messages did not hold true for aversive stimuli.

Labeling Visuals in eLearning: Do They Hurt or Help?
de Koning, van Hooijdonk, Lagerwerf (2017)

Researchers have found that, in multimedia learning (where both text and visuals are used), adding text to visuals can hurt learning when a narration mimics the words presented on the screen.

In this study, researchers wanted to know whether using short labels on screen, instead of more extensive text, would support learning. The elearning demonstrated a behavioral task using an animation—pulling someone to safety away from a dangerous situation. The animation was presented either with or without labels. The results revealed that labels produced better learning retention, especially when presented with an audio voiceover, but did not improve the learners' ability to demonstrate the safety maneuver using a real first-aid dummy.

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[20] The absolute value of Cohen's *d* effect size was .80, coming in at the 60th percentile in comparison with other memory research studies.

When Instructors Draw on Screen: Does It Help or Hurt?

Fiorella & Mayer (2016)

Research sometimes finds a social-facilitation effect in learning situations.

In this set of four experiments, researchers wanted to compare presentations in which an instructor drew diagrams of the Doppler Effect while narrating to presentations where static diagrams were utilized. Over four experiments the results found no differences between conditions on an immediate recall test. However, on more difficult transfer tasks (using the learned information to make decisions) benefits resulted when the instructor was seen drawing compared to when the diagrams were static.

The largest benefits resulted when the instructor's hands were the only part of her body that was shown. When the instructor's full body was shown—clothed in a professional manner—benefits were found compared to static drawings. Having the instructor point to portions of the static drawings did not create benefits in the one experiment where such pointing was used. When drawings were used without the instructor's hand visible, no benefits were found. The researchers concluded that there were socially-enabled benefits when the instructor's hand or body was shown, though there may be some decrements due to distraction when an instructor's full image was shown. Interestingly, a recent study that added an instructor's hand to a video (delivered in a classroom) found that adding the hand actually hurt learning results (Schroeder & Traxler, 2017) rather than helping—contrary to the results reported in this study.

Effortful or Easy Tasks—Comparison Using Mobile Learning Technology

Gao, Liu, & Paas (2016)

Research sometimes finds that, when learners engage in "desirable difficulties," their learning may be facilitated. On the other hand, difficulties can overload working-memory capacity, distract, or otherwise harm learning.

In this research, learners learned about plants—either with the help of (1) QR codes which quickly identified plants and provided information about those plants or (2) with a list of plants that had to be manually sorted by learners, and which, once identified, provided the same information as in the other condition.

The results revealed that, for tasks with relatively low cognitive load, manual sorting provided some benefits unless there were too many plants to sort through. In relatively high cognitive-load tasks, QR codes improved learning results.

Summary of eLearning Research—When Learning Methods Compared

There are many studies that utilize elearning to compare different learning methods—sometimes because the researchers are interested in providing recommendations for elearning design and sometimes because elearning is a relatively easy way to present experimental participants with learning materials.

The research comparing different elearning methods tells us several things about the viability of elearning. First, elearning can target many types of learning. As evidenced in the research cited, elearning is not relegated to simple learning materials or trivial tasks. In this batch of studies, learners engaged in learning how to conduct forensic interviews, solve linear algebra problems, make sense of cerebral hemorrhages, pull a person to safety, understand the Doppler Effect, and identify plants and their attributes. Second, researchers are working to ensure that elearning is as effective as it can be. Third, researchers are confident enough in elearning that they use it to test theories of learning and cognition—and report these results to other scientists.

SECTION 4—Meta-Analysis on Technologies Similar to, or Utilized in, eLearning

So far in this report, we've focused on elearning or blended learning that utilizes elearning. To provide additional perspective, this section will look at meta-analyses of similar or intersecting learning technologies.

Digital Simulations in Medical Education

Cook (2014)

Cook did a cumulative meta-analysis examining scientific studies that utilized simulations in medical education. Looking at most of the years from 1973 to 2012, he found that every year produced results that favored simulation over no simulation. Since the year 2000, effect sizes have ranged from 1.01 to 1.10, showing the effectiveness of simulations in medical education.

Digital Simulations in Medical Education

Cook, Hatala, Brydges, Zendejas, Szostek, Wang, Erwin, & Hamstra (2011).

Looking at more than 600 scientific studies of technology-enabled simulations in the medical profession, this set of researchers found large effect-size improvements for multiple outcomes. In comparison with no intervention, effect sizes were 1.20 for knowledge outcomes, 1.14 for time skills, 1.09 for process skills, 1.18 for product skills, 0.79 for time behaviors, 0.81 for other behaviors, and 0.50 for direct effects on patients. Although they found relatively large effect sizes, they compared simulations to no other intervention, so we would expect significant levels of improvement. This comparison is not nearly as relevant as comparing simulations to another learning method.

Computer-Based Simulation Games

Sitzmann (2011).

Examining 40 rigorously-designed scientific studies on computer-based simulation games, the results revealed that, *"trainees receiving instruction via a simulation game had higher levels of declarative knowledge (d = .28), procedural knowledge (d = .37), and retention (d = .22) than trainees in the comparison group… Learning from simulation games was maximized when trainees actively rather than passively learned work-related competencies during game play, trainees could choose to play as many times as desired, and simulation games were embedded in an instructional program rather than serving as stand-alone instruction.*

Feedback in Computer-Based Training

Azevedo & Bernard, 1995

Looking at research studies that compared situations where learners got feedback or didn't, researchers found an effect size of .80, showing a benefit to providing feedback.

Animations Compared with Static Pictures

Höffler & Leutner (2007)

Research comparing the use of animations in comparison with static pictures found, overall, an effect size of *d* = 0.37—a small to medium effect size, showing an advantage for animations.

Digital Games Compared with Non-Game Interventions

Clark, Tanner-Smith, & Killingsworth (2016)

Researching computer-based games in comparison to conditions where games were not in use, this meta-analysis revealed that game conditions outperformed non-game conditions, with an effect size of .33. Moderator analysis showed that multiple game sessions produced greater results than single sessions. It also showed that games that were enhanced by their designers produced larger learning improvements than standard versions.

Learner Control in Learning Technology

Karich, Burns, & Maki (2014)

This research compared learning technologies that gave learners different levels of control over the pace of learning, the path taken through the learning materials, or the instructional approach utilized. The meta-analytic findings revealed no overall benefit to giving learners control, finding a non-significant effect size of .05, which would put it at the 1 percentile mark, meaning about 99% of all other scientific studies in the memory-research area would outperform it.

Blended Learning in Health Professions

Liu, Peng, Zhang, Hu, Li, & Yan (2016)

Researching blended learning in the health professions, this study compared blended learning to either classroom training or elearning—and revealed a non-significant effect size after correcting for possible publication bias, with a *d* = .26.

Computer-Mediated Language Learning

Lin (2015)

This research looked at computer-mediated language learning—where learners communicate with one or more other people via computer (including through *"e-mail, chat, video/audio conferencing, discussion forums, CMS, Moodle, etc.")*. It found a moderate effect size of .44, indicating that computer-mediated language learning outperformed comparison groups who got other interventions or no interventions at all. The inclusion of some studies that compared computer-mediated learning to no intervention necessitates two conclusions. First, the results cannot suggest that computer-mediated language learning outperforms classroom instruction. Second, computer-mediated language learning is generally helpful in supporting learning, but we can't tell if other interventions might be more effective.

Interactive versus Didactic Computer-Assisted Instruction

Thomas, Alexander, Jackson, & Abrami (2013)

This study looked at computer-assisted instruction and compared two different meta-designs, what the researchers haphazardly labeled "interactive" and "didactic." "Didactic" was defined as a learning approach where *"teachers choose the content and the pace of instruction and transmit information to students, while students work on well-structured problems with pre-defined answers."* "Interactive" learning environments were defined as places where *"students are actively engaged in the learning process through activities such as simulations and discussion forums. Moreover, students have the ability to choose instructional material and to navigate through it at their own pace."* While the distinctions drawn are not necessarily consistent with the common definition of "didactic" and "interactive"—and the authors admit that they had difficulty placing different learning designs into the two categories—they did find a small comparative benefit to the "interactive" designs compared with the more "didactic" designs, with an effect size of .175, a small effect size that compares to other memory research at about the 10th percentile. The authors note that their results are not consistent with some earlier results (i.e,. Lee, 1999; Rosen & Salomon, 2007). Hence, we should take these results with some skepticism.

eLearning Acceptance by Prospective Learners

Abdullah & Ward (2015)

This review looked at research on learner perceptions of elearning with the goal of creating a model for the external factors that influence learner acceptance and likelihood of fully engaging with elearning. Working from a previously validated model, TAM, the Technology Acceptance Model (Davis, 1986), this meta-analysis extended that model to the precipitating factors that affect the first causal nodes in TAM—the perceived usefulness of the technology and the perceived ease of use. These two factors are thought to influence learners' attitudes and their intention to use the technology, which, in turn, influence the actual use of the technology. Based largely on learner perceptions—which may or may not be fully valid—this meta-analysis found five precursor factors, including a learner's previous experience, the subjective norms of the learning context, the amount of enjoyment reported, computer anxiety, and a person's self-efficacy.

Summary of Meta-Analyses Relevant to eLearning

The breadth and depth of research relevant to elearning is stunning. In these 10 meta-analyses—and this is just a random sampling—we can see researchers have focused on simulations, simulation games, feedback, animations, digital games, learner control, computer-mediated language learning, interactivity, and elearning acceptance. As can be seen by looking at these topics, these learning-technology researchers are investigating learning methods that tend to go beyond those we typically use in classroom instruction. Yes, we can use most of these methods in face-to-face instruction, but we typically don't. Overall, these meta-analyses provide us with additional evidence that learning technologies are generally beneficial in supporting learning (though not necessarily better than non-technology interventions), that some technology-based learning methods are better than others, and that there is a great deal of variability in the research results.

CONCLUSIONS

In terms of learning effectiveness, it is NOT whether the modality is elearning or classroom instruction; the learning methods are what make the difference. Realistic decision making, spaced repetitions, real-world contexts, and feedback—among other research-supported learning factors—produce better learning than straight information presentation. When learning methods are held constant between elearning and classroom instruction, both will tend to produce equal results.

The research findings also showed that, when elearning and classroom instruction were blended (used together), learning results were better than if elearning or classroom learning were utilized alone. On average, despite some variability, elearning tended to outperform traditional classroom instruction—likely owing to the differing learning methods used.

The bottom line is that, when more effective learning methods are used, better learning outcomes are achieved.

Conclusions from the Research Reviewed

1. When learning methods are held constant between elearning and classroom instruction, both produce equal results.
2. When no special efforts are made to hold learning methods constant, eLearning tends to outperform traditional classroom instruction.
3. A great deal of variability is evident in the research. eLearning often produces better results than classroom instruction, often produces worse results, often similar results.
4. What matters, in terms of learning effectiveness, is NOT the learning modality (elearning vs. classroom); it's the learning methods that matter, including such factors as realistic practice, spaced repetitions, real-world contexts, and feedback.
5. Blended learning (using elearning with classroom instruction) tends to outperform classroom learning by relatively large magnitudes, probably because the elearning used in blended learning often uses more effective learning methods.

Practical Recommendations for Learning Professionals

What should elearning developers, instructional designers, trainers, and chief learning officers make of this research? The most important point is this: When creating your learning interventions, focus your energies on utilizing research-based learning factors that work! Utilize guidance from research-to-practice experts—for example, in research compilations (e.g., The Decisive Dozen, the eLearning Manifesto). Utilize wisdom from books that compile research findings (e.g., Make it Stick, Design for How People Learn).

Focus on the most important learning factors first. Be sure you are utilizing methods such as realistic retrieval practice, spaced repetitions, and feedback—among many other proven research-based learning factors. Avoid ineffective learning methods like learning styles (see http://www.debunker.club/). Avoid fads like neuroscience or brain science—which, to date, have only been able to reinforce behavioral research findings[21] and which, unfortunately, are prone to misstatements and overhyped claims from unscrupulous vendors in the learning field.

Utilize a rigorous instructional design process—first determining needs and deciding what you're trying to accomplish, and only then determining whether to build with classroom training or elearning (or perhaps using performance support or a non-learning intervention).

Don't assume elearning is best. Don't assume classroom instruction is best. Also, don't assume learning methods traditionally utilized in one modality can't be utilized in another. We saw in the research review how even such classroom staples as role plays and discussions can be successfully utilized online. We should also be aware that interactive learning methods typically used in elearning can also be parlayed successfully in classroom instruction.

The breadth and depth of the elearning research reviewed in this report parallels the explosion of elearning technologies in the learning industry. In some sense, we are in a great pioneering phase. Together, as an industry, we are rapid-prototyping our way to the future of elearning. Based on this accelerating trend alone—combined with evidence that elearning can be effective—it is recommended that learning professionals become conversant in elearning methodologies and pilot test real-world elearning applications using continuing rounds of improvement. Such work will not only improve learning results, but will prepare us as learning professionals for the future of elearning.

[21] Thalheimer, W. (2016). Brain-Based Learning and Neuroscience—What the Research Says!

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