Technical Appendix

Digital Technology

Definition

Digital technology is mainly associated with computer-assisted strategies to support learning within schools. Approaches in this area are very varied, but a simple split can be made between: 1. Programmes for students, where learners use technology in problem solving or more open-ended learning, and 2. Technology for teachers such as interactive whiteboards or learning platforms.

Search Terms: digital technology; word processing computer/education technology; online/e-learning; computer assisted instruction

Evidence rating

There are 12 meta-analyses and quantitative syntheses suggesting positive impact on students’ learning. However, the variation in effects and the range of technologies available suggest that it is important to evaluate the impact on learning when technology is used. Average impacts have remained consistent across times suggesting that general messages are likely to remain relevant. Overall, the evidence is rated as extensive.

References

<table>
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<th>Full references</th>
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*studies included in the summary of effects

References for Australasia-specific studies can be found in the *Australasian Research Summary* for this topic, available as a link on the Toolkit page.
Summary of effects

<table>
<thead>
<tr>
<th>Study/Meta-analyses</th>
<th>Effect size</th>
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<tbody>
<tr>
<td>Bayraktar, 2000 (science)</td>
<td>0.27</td>
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<tr>
<td>Camnalbur &amp; Erdogan, 2010 (in Turkey)</td>
<td>1.05</td>
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<tr>
<td>Cheung &amp; Slavin, 2011 (on mathematics)</td>
<td>0.15</td>
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<tr>
<td>Christmann &amp; Badgett, 2003</td>
<td>0.34</td>
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<tr>
<td>Li &amp; Ma 2010 (on mathematics)</td>
<td>0.71</td>
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<tr>
<td>Liao, 2007 (in Taiwan)</td>
<td>0.55</td>
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<tr>
<td>Pearson, 2005 (on reading)</td>
<td>0.49</td>
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<tr>
<td>Sandy-Hanson, 2006 (general academic)</td>
<td>0.28</td>
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<tr>
<td>Tamim et al., 2011 (general academic)</td>
<td>0.35</td>
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<tr>
<td>Torgeson &amp; Elbourne, 2002 (on spelling)</td>
<td>0.37</td>
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<tr>
<td>Torgeson &amp; Zhu, 2003 (on reading)</td>
<td>-0.05</td>
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<tr>
<td>Torgeson &amp; Zhu, 2003 (on spelling)</td>
<td>0.02</td>
</tr>
<tr>
<td>Torgeson &amp; Zhu, 2003 (on writing)</td>
<td>0.89</td>
</tr>
<tr>
<td>Waxman, Lin &amp; Michko, 2003 (cognitive outcomes)</td>
<td>0.44</td>
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Weighted Effect Size 0.28

For more information about the effect sizes in the Toolkit, click [here](#).

Meta-analyses abstracts

<table>
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<tr>
<th>Study</th>
<th>Abstract</th>
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<tr>
<td>Bayraktar S. (2000)</td>
<td>This meta-analysis investigated how effective computer-assisted instruction (CAI) is on student achievement in secondary and college science education when compared to traditional instruction. An overall effect size of 0.273 was calculated from 42 studies yielding 108 effect sizes, suggesting that a typical student moved from the 50th percentile to the 62nd percentile in science when CAI was used. The results of the study also indicated that some study characteristics such as student-to-computer ratio, CAI mode, and duration of treatment were significantly related to the effectiveness of CAI. (Keywords: academic achievement, computer-assisted instruction, instructional effectiveness, meta-analysis, science education.)</td>
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<tr>
<td>Camnalbur &amp; Erdogan (2010)</td>
<td>Studies focusing on the effectiveness of computer-assisted instruction have been growing recently in Turkey. In this research, quantitative studies comparing the effectiveness of computer-assisted instruction to traditional teaching method and conducted between 1998 and 2007 are studied by meta-analysis. Seventy eight studies that have eligible data were combined with meta analytical methods by coding protocol from the 422 master’s and doctoral degree and 124 articles. As a result for the study, the effect size of computer-assisted instruction method for academic achievement calculated 1.048. This is large scale according to Thalheimer and Cook, large and Cohen, Welkowitz and Ewen (2000). Recommendations were made based on the results of the study.</td>
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<tr>
<td>Cheung &amp; Slavin (2011)</td>
<td>The present review examines research on the effects of technology use on reading achievement in K-12 classrooms. Unlike previous reviews, this review</td>
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applies consistent inclusion standards to focus on studies that met high methodological standards. In addition, methodological and substantive features of the studies are investigated to examine the relationship between education technology and study features. A total of 85 qualified studies based on over 60,000 K-12 participants were included in the final analysis. Consistent with previous reviews of similar focus, the findings suggest that education technology generally produced a positive, though small, effect (ES=+0.16) in comparison to traditional methods. However, the effects may vary by education technology type. In particular, the types of supplementary computer-assisted instruction programs that have dominated the classroom use of education technology in the past few decades are not producing educationally meaningful effects in reading for K-12 students. In contrast, innovative technology applications and integrated literacy interventions with the support of extensive professional development showed somewhat promising evidence. However, too few randomized studies for these promising approaches are available at this point for firm conclusions.

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<tr>
<th>Study</th>
<th>Description</th>
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<tr>
<td>Christmann &amp; Badgett 2003</td>
<td>This meta-analysis compared the academic achievement of elementary students who received either traditional instruction or traditional instruction supplemented with CAI. From the 68 effect sizes, an overall mean effect size of 0.342 was calculated, indicating that, on average, students receiving traditional instruction supplemented with CAI attained higher academic achievement than did 63.31% of those receiving only traditional instruction. However, a -0.463 correlation between effect size and years indicates that the effect of CAI on academic achievement has declined between the years 1969 and 1998.</td>
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<tr>
<td>Li &amp; Ma (2010)</td>
<td>This study examines the impact of computer technology (CT) on mathematics education in K-12 classrooms through a systematic review of existing literature. A meta-analysis of 85 independent effect sizes extracted from 46 primary studies involving a total of 36,793 learners indicated statistically significant positive effects of CT on mathematics achievement. In addition, several characteristics of primary studies were identified as having effects. For example, CT showed advantage in promoting mathematics achievement of elementary over secondary school students. As well, CT showed larger effects on the mathematics achievement of special need students than that of general education students, the positive effect of CT was greater when combined with a constructivist approach to teaching than with a traditional approach to teaching, and studies that used non-standardized tests as measures of mathematics achievement reported larger effects of CT than studies that used standardized tests. The weighted least squares univariate and multiple regression analyses indicated that mathematics achievement could be accounted for by a few technology, implementation and learner characteristics in the studies.</td>
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<td>Liao (2007)</td>
<td>A meta-analysis was performed to synthesize existing research comparing the effects of computer-assisted instruction (CAI) versus traditional instruction (TI) on students’ achievement in Taiwan. Fifty-two studies were located from our sources, and their quantitative data was transformed into effect size (ES). The overall grand mean of the study-weighted ES for all 52 studies was 0.55. The results suggest that CAI is more effective than TI in Taiwan. In addition, two of the seventeen variables selected for this study (i.e., statistical power, and comparison group) had a statistically significant impact on the mean ES. The results from this study suggest that the effects of CAI in instruction are positive over TI. The results also shed light on the debate of learning from media between Clark and Kozma.</td>
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<tr>
<td><strong>Paper</strong></td>
<td><strong>Abstract</strong></td>
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<td>Pearson (2005)</td>
<td>This article reports the results of a meta-analysis of 20 research articles containing 89 effect sizes related to the use of digital tools and learning environments to enhance literacy acquisition. Results (weighted effect size of 0.489) demonstrate that technology can have a positive effect on reading comprehension, but little research has focused on the effect of technology on metacognitive, affective, and dispositional outcomes. We conclude that although there is reason to be optimistic about using technology in middle-school literacy programs, there is also reason to encourage the research community to redouble its emphasis on digital learning environments for students in this age range and to broaden the scope of the interventions and outcomes they study.</td>
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<td>Sandy-Hanson 2006</td>
<td>Meta-analytical research has shown that computer technology can play a significant role in increasing positive learning outcomes of students. Research on this topic has resulted in conflicting findings on academic achievement and other measures of student outcomes. The current meta-analysis sought to assess the level of differences that existed between students being instructed with computer technology versus the academic achievement outcomes of students instructed with traditional methods. Based on specified selection criteria, 31 studies were collected and analyzed for homogeneity. From this original group, 23 studies were systematically reviewed under standard meta-analytical procedures. According to Cohen's (1988) classification of effect sizes in the field of education, the obtained weighted mean effect size of .24 shows a medium difference. This finding indicates that students who are taught with technology outperform their peers who are taught with traditional methods of instruction. In addition, five secondary analyses were conducted on higher-order thinking skills, ES = .82, motivation, ES = .17, retention-attendance rates, ES = .16, physical outcomes, no data were found, and social skills, ES = .21. Eleven ancillary analyses were then conducted to assess study findings across various dimensions including duration of study, type of technology used, and grade-level analyzed.</td>
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<td>Tamim et al., (2011)</td>
<td>This research study employs a second-order meta-analysis procedure to summarize 40 years of research activity addressing the question, does computer technology use affect student achievement in formal face-to-face classrooms as compared to classrooms that do not use technology? A study-level meta-analytic validation was also conducted for purposes of comparison. An extensive literature search and a systematic review process resulted in the inclusion of 25 meta-analyses with minimal overlap in primary literature, encompassing 1,055 primary studies. The random effects mean effect size of 0.35 was significantly different from zero. The distribution was heterogeneous under the fixed effects model. To validate the second-order meta-analysis, 574 individual independent effect sizes were extracted from 13 out of the 25 meta-analyses. The mean effect size was 0.33 under the random effects model, and the distribution was heterogeneous. Insights about the state of the field, implications for technology use, and prospects for future research are discussed.</td>
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<td>Torgeson &amp; Elbourne, (2002)</td>
<td>Recent Government policy in England and Wales on Information and Communication Technology (ICT) in schools is heavily influenced by a series of non-randomised controlled studies. The evidence from these evaluations is equivocal with respect to the effect of ICT on literacy. In order to ascertain whether there is any effect of ICT on one small area of literacy, spelling, a systematic review of all randomised controlled trials (RCTs) was undertaken. Relevant electronic databases (including BEI, ERIC, Web of Science, PsycINFO, The Cochrane Library) were searched. Seven relevant RCTs were...</td>
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identified and included in the review. When six of the seven studies were pooled in a meta-analysis there was an effect, not statistically significant, in favour of computer interventions (Effect size =0.37, 95% confidence interval=70.02 to 0.77, \( p=0.06 \)). Sensitivity and sub-group analyses of the results did not materially alter findings. This review suggests that the teaching of spelling by using computer software may be as effective as conventional teaching of spelling, although the possibility of computer-taught spelling being inferior or superior cannot be confidently excluded due to the relatively small sample sizes of the identified studies. Ideally, large pragmatic randomised controlled trials need to be undertaken.

### Torgeson & Zhu (2003)

The overall aim of the two-year project is to determine the impact of ICT on literacy learning in English for 5-16 year olds. The main aim of this in-depth sub-review is to investigate whether or not ICT is effective in improving young people’s literacy learning in English. Subsidiary aims are to assess the effectiveness of ICT on different literacy outcomes and, within those outcomes, to assess whether effectiveness varies according to different interventions. For this review, studies were only included if they had randomly allocated pupils to an ICT or no ICT treatment for the teaching of literacy. Both individually randomised trials and cluster randomised trials were included. We identified 12 relatively small RCTs for the in-depth review. Some were so small that they could only really be considered to be pilot studies. This group of tiny trials represent the sum of the most rigorous effectiveness evidence available to date upon which to justify or refute the policy of spending millions of pounds on ICT equipment, software and teacher training. Given that the trials showed little evidence of benefit large, rigorously design, randomised trials are urgently required.


To estimate the effects of teaching and learning with technology on students’ cognitive, affective, and behavioral outcomes of learning, 282 effect sizes were calculated using statistical data from 42 studies that contained a combined sample of approximately 7,000 students. The mean of the study-weighted effect sizes averaging across all outcomes was \( \mu = .410 \) (\( p < .001 \)), with a 95-percent confidence interval (CI) of \( .175 \) to \( .644 \). This result indicates that teaching and learning with technology has a small, positive, significant (\( p < .001 \)) effect on student outcomes when compared to traditional instruction. The mean study-weighted effect size for the 29 studies containing cognitive outcomes was \( .448 \), and the mean study-weighted effect size for the 10 comparisons that focused on student affective outcomes was \( .464 \). On the other hand, the mean study-weighted effect size for the 3 studies that contained behavioral outcomes was \( -.091 \), indicating that technology had a small, negative effect on students’ behavioral outcomes. The overall study-weighted effects were constant across the categories of study characteristics, quality of study indicators, technology characteristics, and instructional/teaching characteristics.