Technology plays an important role in almost every aspect of modern life, and the education sector is no exception. The two most obvious applications of technology in education are online and blended (i.e., a combination of face-to-face and online) learning programmes, but technology is also an increasingly common teaching tool in traditional brick-and-mortar schools. The COVID-19 pandemic highlighted the apparent benefits of using technology in education and enabled students to continue learning even when brick-and-mortar schools were closed. However, the influence of digital technologies on learning outcomes in general is still under debate, especially when we look beyond the relatively superficial question of whether educational technology works and instead examine the nuances of when and for whom it works better. Policymakers at ministries of education and administrators in educational institutions need to consider multiple criteria closely before making investments in educational technologies in schools or creating dedicated online learning opportunities. While access to technologies such as computers and mobile devices is increasing and there have been numerous studies on how technology can influence learning, it is important to step back and review those studies in order to improve our shared understanding of the topic and subsequently make more effective use of the technology. In this summary we present the results of a second-order meta-analysis to highlight and share the findings and lessons learned to date.

To achieve our objective of assessing the effectiveness of technology as an educational tool in face-to-face, online and blended learning environments, we conducted a systematic examination of the relevant research through a second-order meta-analysis. Broadly speaking, a second-order meta-analysis is a systematic review of reviews, which synthesises findings from existing first-order meta-analyses of the research in a form of aggregated effect size. Effect size is a metric that assesses the magnitude of the difference between educational interventions in question – in this case, use of technology and its alternative – in this case, traditional teaching unsupported by technology use. Second-order meta-analysis also considers biases and errors in the earlier research, including possibly overestimated effect sizes.

Keeping in mind the danger of exaggerated effect sizes, we followed standard rigorous research procedures to identify 131 first-order meta-analyses that covered a variety of educational settings, types of technology, grade levels and subject matters. We organised the findings according to the type of educational setting — in-class, online and blended — and broke them down within those categories by moderator variables such as the type of technology and its primary use, grade level/age of the students using the technology, the subject being taught, the date the study was published and how representative the study was. These moderator variables allowed us to examine more closely the associated effect...
sizes and to assess how much influence a factor, or set of factors, has on the overall outcome of an activity. In this case, the question of interest was how much learning outcomes were affected by the application of educational technology.

In-Class Technology Integration

Ninety-four of the meta-analyses concerned the application of technology in a traditional, face-to-face classroom setting with overall effects of between 0.34 and 0.41. These findings indicated that when technology is used in this context, students’ learning performance improved between 10 and 11.5 percentage points. The positive effects were especially observed when the technology was used for teaching language arts, including reading, writing and learning a second language. While it seems reasonable to conclude that technology could ultimately improve learning outcomes in a face-to-face classroom setting, administrators, policymakers and other stakeholders with responsibility for budgets may need to review the current use of technology in classrooms and the cost-effectiveness of specific tools/applications for future interventions systematically to achieve improvement in learning outcomes.

Online Learning

As for the use of technology in online learning environments, we found 11 meta-analyses that examined the effective use of technology with an overall weighted average effect size of 0.16. This translates into only 2.4% improvement in learning outcomes. However, the meta-analyses support the findings of earlier research, some of which dates back 20 years, which concluded that students who studied at a distance had comparable learning outcomes to those who studied in a traditional, face-to-face classroom, but in terms of improved learning outcomes, the difference was very small. As was observed with the transition to online learning during the early months of the COVID-19 pandemic, online learning opens up access to education anywhere, anytime. It is particularly suitable for students who live in remote areas or who have family or work commitments and need a more flexible schedule to allow them to learn where and when it is convenient. However, the costs of setting up an effective online learning environment — including acquiring the technical infrastructure, training teachers and adapting curricula and learning material — can be significant, and so, to achieve economies of scale, spending on such programmes must be treated as a long-term investment, while also taking into account challenges of the other nature – e.g., issues of social isolation, self-discipline, time management, etc. Furthermore, students can only participate in online learning programmes if they have access to the required infrastructure and technology, and their success is dependent in large part on their having a physical space at home or in their wider community where they can learn and study with no distractions or interruptions. In addition, earlier positive findings could be attributed in part to the fact that the data in those studies were based on the experiences of students who had actively chosen to participate in online learning (thus suggesting an interest in their studies, and a willingness and ability to pursue them). Without these conditions in place, online learning may prove ineffective or even counterproductive, and students who live in low socio-economic environments may be excluded from online learning simply because these conditions are not in place for them. Therefore, online learning design and implementation must focus on the twin issues of equity and inclusion to provide quality education for all.

Blended Learning

The third learning category addressed in this second-order meta-analysis was blended learning, which, as its name suggests, is a combination of traditional, face-to-face learning and online learning. We synthesised findings from 13 meta-analyses that addressed the effect of technology on learning in this type of environment with average effect sizes ranging between 0.38 and 0.47. This translates into a 10.7% average improvement in academic performance compared to face-to-face instruction. Our results showed that while the application of technology in a blended learning environment led to only low to moderate improvement in students’ learning outcomes, those students still
performed consistently better than their counterparts who received traditional face-to-face or online-only instruction. In the past, blended learning has been described as “the best of both worlds,” and the learning outcomes appear to support this claim. From an implementation perspective, blended learning could be more successful at improving learning outcomes, and because it can be built on the existing infrastructure, it could lead to substantial savings. An effective blended learning environment essentially needs an expanded version of the resources available for face-to-face teaching and appropriately designed courses that draw from the best of both online and traditional learning environments.

More Lessons

In addition to looking at academic outcomes in different learning environments, we also looked at certain moderator variables within each type of the included meta-analyses (i.e., factors that can influence the relationship between academic outcomes and learning environment): subject matter, grade level/age, and time scale.

- When we analysed the application of educational technology by subject matter, we found that it was particularly suited to language learning, and especially second language acquisition. While no specific reason for this could be ascertained, the early use of technology applications for language learning may have contributed to the development of more appropriate models and instructional design in this sector. In addition, the benefits of using mobile applications for vocabulary learning in particular (e.g., the ability to access a word’s meaning at will) were consistently observed. This topic merits further research, as it could provide more insight into practices and changes that might render educational technology applications more effective in other subjects.

- From the studies covered, we found very little difference in effect sizes for learning outcomes among learners of different ages and grade levels. We can reasonably assume from this that the technological tools and their applications in these studies were carefully selected to meet the needs of the learner group. As the effect size was above 0.4 on average, it looks likely that the appropriate tools could improve student learning moderately irrespective of grade level.

- One of the challenges of studying the impact of technology over time is the sheer speed at which the technology changes. To have a better overview of the longer-term impact of technology on learning outcomes, we separated out the meta-analyses under investigation by publication date: published between 2000 and 2010 (inclusive) and published in 2011 and later. We discovered that the more recent meta-analyses tended to report slightly higher average effect sizes than the earlier ones. Even when we accounted for a degree of overlap between the two groups, we concluded that in-class technology integration gradually gains in effectiveness over time, the tendency not observed in many previous reviews. This shows the maturation of the understanding of the use of technology for teaching and learning and the growth in teachers’ ability to improvise and modify the instructional design over time, leading to improved effectiveness.

- The use of a flipped classroom produced slightly better effect sizes than other forms of blended learning. This means that using online mini-lectures prior to in-class active learning could be a good way to improve student learning outcomes.
It is increasingly unusual for a face-to-face classroom to be completely technology-free, even in some poorer parts of the world. When we looked at the application of technology in education, we realised that we could learn very little by looking at studies that compare learning environments that use technology for learning to any degree with learning environments that are completely technology-free. These types of comparative studies would not allow us to explore and understand what technologies work better (or worse) for whom, under what circumstances and why.

If we want to truly expand and solidify our understanding of the true potential of educational technology and guide its meaningful application in a learning context, we need to look at studies that compare different uses or applications of the same technological tools, as they are guided by instructional design and pedagogical strategies.

We must understand and appreciate the advantages and disadvantages of new and emerging technologies before they are displaced by something even more new and exciting, not only to assess their impact but also to learn from our mistakes and avoid repeating them. Furthermore, future research should include more in-depth analysis of moderator variables in the studies of well-established educational technologies by going beyond assessments of basic demographics and contextual features towards in-depth examination of more nuanced characteristics of what instructional purpose the technology under consideration serves and what pedagogical principles underlie its use.

As technology becomes an increasingly commonplace tool in educational settings of all descriptions around the world there will be an increasing need to monitor its effectiveness and assess its benefits and drawbacks. If we are to stay abreast of developments in technology, the use of technology in an educational setting and the effectiveness of using technology in an educational setting, it is crucial that robust independent literature reviews — including both first-order and second-order meta-analyses — are conducted regularly. Follow-up meta-analyses should also bring us closer to identifying the elusive “something” that students gain from learning in a classroom-based/online learning environment. That in turn will help us to understand the optimal balance between in-class and online learning and to work towards establishing best practices, strategies and techniques for technology-supported blended learning.


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