Beyond the hype

Digital learning based on learning science

Investment in educational technology is rising at breakneck speed. Last year, global investments in the sector jumped over 70%. Across the world, in school classrooms and university lecture halls, many have reported on the benefits it can bring to enhance, simplify, support and scale teaching and learning. But just making technology available is not enough. To achieve successful outcomes, technology must be carefully deployed alongside the best pedagogical practices and discipline content knowledge.

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This evidence-based paper brings together what the education community has to say on the value of digital education, offers practical guidance for educators and leaders on where to begin the journey to delivering better outcomes using technology, and what to be mindful of along the way.

About the author

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Educational technology supports teachers and learners.

Technology alone is not the magic answer. But when designed and implemented well, it has the potential to enhance, simplify, support and scale a number of teaching and learning activities.

Rather than starting with shopping for educational technology, start with understanding the problems that educators and learners experience. Look to see whether educational technology can help solve those problems.

The table below shows how technology can help address a number of learner and educator pain points.

PROBLEM	SOLUTION	EXAMPLE
Educator: Different students struggle with different aspects of the material, and hold a variety of misconceptions. It is difficult to have an in-depth understanding of this for my whole class.	**Insight and analytics** Technology can: ■ gather highly detailed information about each student ■ aggregate information consistently ■ surface trends through analytics and machine learning ■ provide this in easily intelligible visualizations that support pedagogical actions ■ allow for more frequent assessment, so that student needs can be reviewed more often	If students are playing a game that teaches the concept of geometric area, the game can gather information about who understands the concept deeply as opposed to who is only able to apply the formula proficiently, based on how the students manipulate objects in the game. Information about the progress of students in conceptual understanding can be displayed for educators in real time.
Educator: I have a large class of students with differing abilities, interests, and goals, and it's difficult to pitch the content and support at the right level for everybody. **Learner:** When work is too hard, I get frustrated. When work isn't relevant I tune out.	**Personalized activity selection** Technology can create multiple activities from templates, and some of those can be further customized based on a variety of factors, producing individualized choices for students that take into account students' abilities, interests, and needs.	Learners could receive algebra problems tailored to their own interests[1] or a worked example could be generated that helps a learner compare an error they made to the correct procedure.[2]
Educator: My students are at different levels, and so they need a variety of supports during different parts of their learning process. **Learner:** The kind of support I need when I am just starting out is very different than what I might need as I am practicing and learning.	**Personalized feedback** Technology can give each student specific feedback, even on a step-by-step basis, as the learner works.	A student is completing a calculus problem. They submit their written solution to an app. The app indicates whether each step is correct. Next to an incorrect step it also notes, "Try the chain rule. Click here for a video about applying the chain rule."
Educator: My students focus on getting through learning activities as quickly as possible, rather than engaging deeply. **Learner:** I don't always know how to best proceed through learning activities, so I focus on getting credit.	**Engagement** Digital technologies are becoming increasingly sophisticated at detecting when students are engaging productively and when they are not, and can adaptively react to maintain student attention.	After a few problems, the student falls into a habit where she enters a wrong answer quickly, just to get these feedback messages which point her in the right way, so the system provides a video walkthrough of the problem to re-engage the learner in thinking deeply about the content.
Educator: I want my students to apply their knowledge and skills to a variety of real world problems. **Learner:** I want to see the relevance of what I am learning.	**More authentic learning & assessment** Digital simulations allow learners to immerse themselves in a variety of environments similar to those in the real world where they can experiment without risk.	A geology teacher assigns a simulation for homework in which students must use various virtual tools and measurements to predict where and when an earthquake is likely to occur, much like a real geologist would.
Educator: I want my students to engage in deeper learning activities, but it is hard to regularly find time in the semester to give detailed feedback.	**Shifting teacher focus** Learning technologies are becoming more sophisticated in the kinds of skills they can assess, such as inquiry[3] and writing,[4] freeing up more instructor time from observing and grading to providing deeper feedback and deciding how to move students forward.	The teacher can see real-time updates on individual and class-level performance on this homework, so that he can adjust his lesson plans to focus on the most critical information.

Impact at scale

Technology can allow for two aspects of scaling good teaching practice. First, as in the case of immediate feedback, it can scale an effective teaching practice to a number of learners that an educator could not reach alone. Second, it can take over routine tasks, allowing instructors to engage in the more uniquely human tasks at which they excel. For example, there is significant research[5] that shows a relationship with a caring adult is important for at-risk learners. Educators freed from mundane work have more time to focus on building such relationships.

[1] Walkington, 2013
[2] Booth et al., 2013
[3] Sao Pedro, Baker, & Gobert, 2013
[4] Palma & Atkinson, 2018
[5] Eby et al. 2008

The design of digital education products must align with learning science.

To achieve better learner outcomes, digital experiences must be designed so that the technology allows educators and learners to do more of the things research tells us improves learning.

When people think of new learning technologies, they frequently jump to some of the more technologically novel or imaginative possibilities. While emerging technologies (like virtual reality) are very exciting, prior generations got excited about the possibilities of learning afforded by earlier innovations such as film or, even earlier forms of computer-based instruction (which has been in existence for over 50 years). As research over time has demonstrated, the key factor in whether or not a learning experience is effective is not the medium but the instructional methods used. If instructional methods remain the same, new technology will not improve learning.

Four principles of learning

Effective learning is generally the result of learning behaviors and instructional materials that:[6]

1. Focus on clearly defined knowledge and skills (e.g. have learning objectives and minimize distractions)
2. Construct meaning and demonstrate relevance (e.g. move beyond passive learning[7])
3. Provide timely, actionable feedback (e.g. description of how to improve)
4. Align with how memory works (e.g. avoid cognitive overload)

Technology can help facilitate experiences that align with these principles of learning, although there is nothing inherent in technology that guarantees it. Designers of educational technologies can use these principles to build experiences that are likely to lead to better outcomes. Successful learning technologies allow students to be active learners, constructing their understanding of new knowledge and skills through doing.

In summary, effective digital learning experiences do not rely on the novelty of the technology to promote learning; it takes a careful alignment with the science of learning to be confident that the learning technology will successfully help learners.

Tips for younger learners

In addition to these learning principles, more effective apps often allow children to interact with others around the new material.[8] Social interaction could be encouraged by:

- allowing children to remotely work as a group to draw a picture or solve a puzzle
- providing in-app animated characters who respond to a child's choices or speech
- prompting children to discuss the material with parents and caregivers

Tips for older learners

The lack of familiarity with technology and anxiety associated with its use could lower motivation and lead to disengagement. Therefore, in addition to the learning principles set out, it is important for digital technologies to provide:

- adequate scaffolding so that even novice users feel confident and can access the help they need
- guidance on how to navigate the learning environment

[6] Clark & Mayer, 2011; Baume & Scanlon, 2018; Deans for Impact, 2015
[7] Chi, 2009
[8] Hirsh-Patek & colleagues, 2015

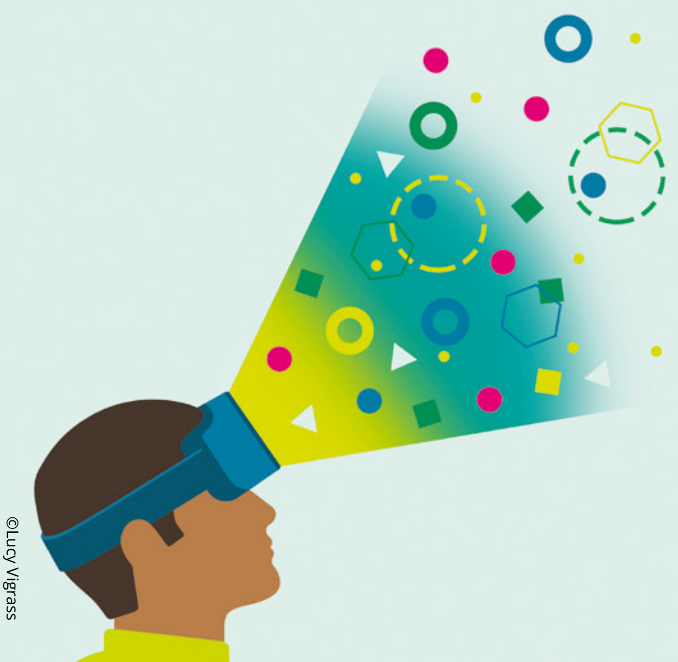
Use technology to do something new.

Digital technology should not be used solely for its own sake. Purely replicating an analog experience with digital technology can add complexity without bringing any accompanying benefits. Instead, technology should be used to change pedagogical practices in ways that enhance learning.

The SAMR model[9]

The SAMR model is a simple framework for thinking about the degree to which any use of digital technology goes beyond the mere replication of an existing analog experience.

		EXAMPLE	
R	**Redefinition** Digital technology enables an entirely new experience	Students work on an interactive simulation to build a nuclear reactor	TRANSFORMATION
M	**Modification** Digital technology is used to redesign an existing experience	Instead of studying a static diagram of a physics concept, students watch a video and predict what happens next	TRANSFORMATION
A	**Augmentation** Digital technology substitutes for analog technology, but with a functional improvement	A diagram on a digital computer displays labels when students click its various parts	ENHANCEMENT
S	**Substitution** Digital technology substitutes directly for analog technology, with no functional improvement	Displaying a diagram on a digital projector instead of an overhead projector	ENHANCEMENT



Use the SAMR model to guide thinking about the degree to which technology can alter previous learning experiences, with the potential impact on learning generally increasing from augmentation to modification to redefinition. The word “potential” is important here, because not every use of technology is necessarily an improvement.[10]

In particular, pure substitution generally does not add pedagogical value because it does not alter the underlying pedagogical approach. Augmentation, modification, and redefinition have the potential to add value by enabling significantly better pedagogical practices, though this is not guaranteed by virtue of introducing technology itself.

[9] Puentedura, 2013 [10] Hamilton, Rosenberg, & Akcaoglu, 2016

How to build an effective digital learning experience.

With constantly changing technologies and highly variable teaching contexts, there is no magic formula to rely on, but these four steps can help educators make informed, effective decisions about technology use.

Four steps to success[11]

	ACTIONS	EXAMPLE
Identify	Define your goal	Helping students who are struggling with algebra because their basic math skills are weak
	Identify the best instruction method	Acquiring skills such as arithmetic computation is best facilitated by extensive practice with immediate feedback
	Research products that match your needs	Look for evidence that use of these products has enhanced learning in this way in the past. Use the SAMR model and TPCK framework (overleaf) to guide your selection
	Appraise the context in which the technology will be used	Address if students will have access to an adequate supply of functioning hardware that meets the products software specifications
Plan	Gain leadership support	Leaders should authorize budget for learning technology, and allocate time for teachers and staff to be sufficiently trained on using technology to improve outcomes
	Ensure you have the appropriate technology infrastructure	Ensure there is sufficient wifi to accommodate the number of users, work with IT to install a compatible browser, and allocate space for a computer lab if this is more suitable for your environment
	Make time within the teaching schedule	Select activities that will work around other commitments in the schedule, or make changes to existing activities to allow time. For example, a 50 minute English class that requires students to read silently for 15 minutes is not going to be able to implement writing instruction software with activities that can't be completed in less than 40 minutes
	Ensure alignment between learning materials and activities	Mathematical operations on positive and negative numbers can be introduced using many different approaches. If the textbook takes one and the software another, students may not realize they are doing the same thing in both
	Articulate roles, training, and ongoing support for educators	Who will enter class rosters, or put content in the system? Educator training should not only cover how the software works, but also recommend instructional practices
Execute	Implement the plan and track progress	Measure the extent to which crucial elements of the plan are put into place if possible, through system log data, structured observation or surveys, and monitor ongoing training needs
Evaluate	Use data to make judgements about the technology supported intervention	A goal of improving students' ability to critically analyze the arguments made in historical texts could be measured using performance data over time, comparing those who completed assignments in new software to those in prior semesters who did not

[11] Means, Murphy, & Shear, 2017

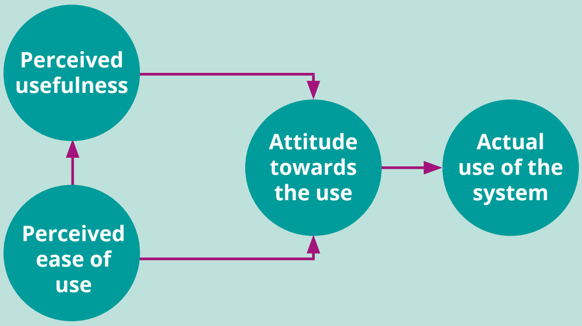
It's all about the people.

Implementing technology can only be successful with people who are bought into using it and who are prepared to make the most of it. In order to get to this place, you will need to overcome skeptics, understand the knowledge and skills needed to teach with technology, and put into place professional development programs that support teaching with technology.

Overcoming skepticism[12]

Users are more likely to adopt technology when they can use it easily and they believe that using it will help them accomplish their goals (as the Technology Acceptance Framework below shows). Numerous studies have shown that across a variety of technology and user types, attitudes about and adoption of education technology are driven in part by these two factors.

The Technology Acceptance Framework[13]



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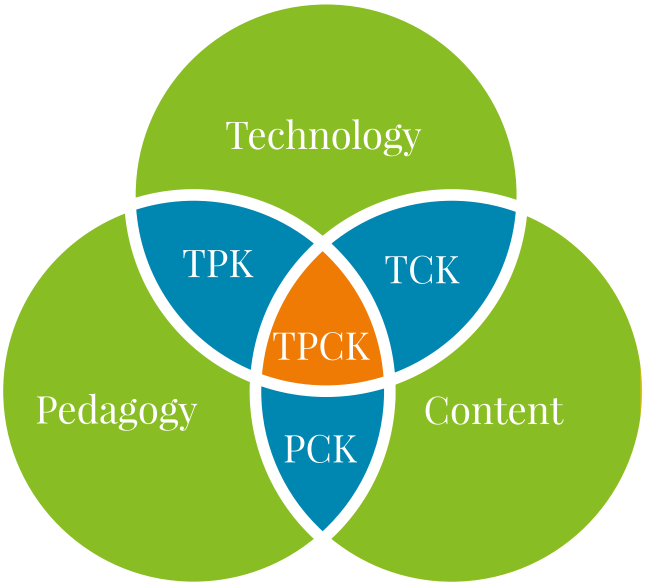
STAKEHOLDER	WHAT CAN HELP
Administration	■ Understand their goals to define the outcomes they want to achieve, and talk about how the technology can help achieve those outcomes ■ Encourage administration to consider a low-cost pilot/trial with a small group before full adoption ■ Use the findings in this paper to enlist support from administration, not just mandating that technology is being used, but also being fully engaged in ensuring better outcomes are being achieved for both learners and teachers ■ Use case studies to show how other institutions have done it successfully
Educators	■ Use the findings in this paper to clearly communicate the value of technology, both practically and pedagogically ■ Arrange group product exploration sessions ■ Work with a small group of teachers who can champion the product ■ Use case studies to show how other educators have done it successfully ■ Adopt user friendly technologies ■ Provide adequate training and support
Learners	■ Adopt user friendly technologies ■ Clearly explain the value of the product in use (using evidence from other students where possible) ■ Train learners on how to use ■ Allow enough time for learners to get familiar with the technology ■ Set out where to go for technical support ■ Students show increasing preference for digital reading when it's not just a substitute for the print experience and moves up the SAMR model (e.g. they use highlighting and annotation features), so choose your technology product carefully[14] ■ Students prefer reading longer texts in print, so consider offering shorter reading tasks digitally
Parents	■ Talk to parents clearly about the value of the chosen product, how it links to results and the support available ■ Show how it can give parents more visibility to track their children's progress

[12] Hew & Brush, 2007
[13] TAM; Davis, 1989; Šumak, Heričko, & Pušnik, 2011
[14] H Mizrachi, Salaz, Kurbanoglu, & Boustany, 2018

The TPCK framework[15]

Apart from winning over skeptics, it is important to understand the skills and knowledge educators must develop and draw upon to design and deliver instruction with technology.



Knowing how to use a technology does not imply knowing how to teach with it in any given domain. Technological Pedagogical Content Knowledge (TPCK) is the intersection of what a teacher knows about their disciplinary content, best pedagogical practices, and technology. Understanding how to positively impact one of these components necessitates consideration of the other two.

Questions to consider:

1. How does the technology permit new pedagogical approaches or place restrictions on current ones?
2. What implications would those changes have for learning goals?
3. Does the technology make new learning goals possible?
4. If so, what changes to pedagogical practice do those require?

A guide to professional development

Professional development must focus on all aspects of an instructor's role in digital teaching and learning. While facilitating digital learning, an instructor plays four main roles:[16]

1. **Pedagogical:** serving as an instructional leader for content, providing input, facilitating learner exploration, assessing learners, providing feedback
2. **Social:** creating a friendly, social environment in which learners feel comfortable interacting with each other and with the instructor
3. **Managerial:** setting and managing course objectives and schedules, managing discussions and interactions
4. **Technical:** understanding and making learners comfortable with the technical aspects of their learning experience (e.g. platform, courseware features)

As with all professional development, teachers benefit most from access to sustained, hands-on experiences that are directly connected to their practice, and allow them to apply and reflect on the success of new skills, strategies, and approaches in their own digital teaching.

Example learning activity
The learning technology by design approach to teacher development has teachers work in small groups to design a technology-based solution to an authentic education problem. This approach may be particularly effective in helping teachers develop integrated knowledge of technology, pedagogy, and content that is necessary for effective use of digital technology to enhance learning.[17]

[15] Mishra & Koehler, 2006
[16] Berge, Z.L., 1995
[17] Voogt, Fisser, Roblin, Tondeur, & van Braak, 2012

Continue the journey to better learning outcomes

We hope this synthesis of research will help to build support for deploying learning technology, hand in hand with the best pedagogical practices, and offer some practical guidance for achieving that.

With thoughtful implementation, and ever-growing sophistication of technology, institutions and educators have the power to break beyond the hype and have a meaningful impact on learner outcomes.

Share your story about using learning technology.
Email us at
efficacy@pearson.com

The Efficacy & Learning Research team focus on the science behind how we help people make progress in their lives through learning.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