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Citation

Ferguson, Rebecca (2019). Pedagogical Innovations for Technology-Enabled Learning. The Knowledge Series; The Commonwealth of Learning, Burnaby, BC, Canada.

URL

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Pedagogical Innovations for Technology-Enabled Learning

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to become world-class doctors in a single day.

These initiatives appear innovative, but they draw on a limited understanding of how people learn. The role of the teacher is seen as something that can

Introduction

What's the weather like on Mars? Does the International Space Station ever get visitors? Today's learners don't need a book to find the answers. They can read the latest social media updates from faraway locations on their computers or handheld devices. What's more, they can chat live with NASA. "How long do astronauts have to train?" enquires a fourth-grade class in Ohio. "About two years... and once you're assigned, there's some more training," respond the astronauts. These opportunities for engagement and communication enable people all over the world to learn something new — either alone or in the presence of others — something that can inspire new questions, interest and enthusiasm.

Technology-enabled learning (TEL) is opening doors to learning opportunities that are unprecedented in human history. Learners and educators make use of new tools and resources and the opportunities they offer for creativity, stimulating inquiry, and working together. These innovations are rooted in pedagogy — approaches to teaching and learning that have a theoretical basis.

The innovations that grab the headlines, though, are typically the ones that are rooted in technology, rather than the ones that make innovative use of pedagogy. A university in London trials the use of hologram lecturers who can talk to students in many rooms at the same time. A school in China monitors student attention in class by using facial-recognition software. An American professor dreams of using artificial intelligence to train individuals

to be improved, simulated by a machine or removed entirely. Knowledge is presented as something that can be consumed, and that must be passed from expert to learner. Learning is treated as a tedious process rather than an engaging and transformative experience.

This view of learning as dull and boring underpins many attempts at educational innovation. The latest technology — which, at different times, has included interactive whiteboards, tablet computers and augmented reality — is used to engage and enthuse learners. This approach often has initial success; learners are interested in novel opportunities and experiences. However, once the technology is no longer new, the approach does not work if there was no pedagogic reason for its use.

In this knowledge series, we cover successful approaches to innovation that are rooted in pedagogy. The following sections introduce both innovation and pedagogy, explaining some of the ways in which technology can be used to support and enable pedagogy. The report goes on to describe a framework for analysing and supporting pedagogical innovations to ensure they have a good chance of success. It concludes by outlining recent pedagogical innovations in TEL that can be trialled in any classroom where learners have access to smartphones and the Internet.

Successful innovations have an enduring positive effect.

In the context of teaching and learning, innovations in pedagogy are key.

Innovation in Teaching and Learning

Broadly speaking, innovation refers to any new development. More specifically, it can be defined as the implementation of new and improved ideas, knowledge and practices. Novelty and change are the main elements of innovation. There is also an assumption that the change is intended to make things better or more effective. Successful innovations have an enduring positive effect.

In the context of industry, where the focus is on increasing output and productivity, there are four main types of innovation. Product innovation introduces a new or significantly improved tool or service, process innovation relates to changes in production and delivery, marketing innovation is concerned with changes to sales methods, and organisational innovation relates to how an organisation goes about its business. In the context of teaching and learning, innovations in pedagogy are key. They may require shifts in product, process, marketing and organisation, but they are driven by an understanding of how people learn.

In this publication, successful TEL innovations are new developments that involve some use of modern technologies and have a positive effect on learners.

Understanding Pedagogy

Successful TEL innovations have a pedagogic rationale. Pedagogy is based on the work of educational theorists who consider what knowledge is and how it is developed or passed on. Pedagogy is also based on the work of educational scientists who study the processes of learning, including how memory works, how skills are developed and how humans make sense of the world.

At a practical level, pedagogy is about using these understandings to support teaching and learning in the classroom or a related environment. Table 1 identifies 16 learning methods informed by the learning sciences. None of these methods requires the use of technology; however, as the right-hand column of the table shows, technology can be used to widen the applications of each method.

LEARNING METHOD	LEARNERS...	USING TECHNOLOGY, LEARNERS...
Assessing	give or receive constructive feedback	engage in online peer review
Browsing	seek and collate information	use search engines to find resources
Case-based	investigate individual cases	investigate medical cases online
Collaborative	construct shared understanding	create a shared Google doc
Construction	create artefacts	build resources in Minecraft
Cross-context	learn across different settings	learn between classroom and home with a smartphone
Conversational	discuss topics	engage in forum discussions
Delivered	listen to a teacher	watch a video
Embodied	learn motor skills	monitor exercise using a smartwatch
Game-based	play educational games	join multiplayer educational games
Inquiry-driven	investigate authentic situations	use digital tools to collect and analyse data
Networked	interact with networks of peers	link to others via social media
Performative	present to an audience	blog about their learning
Problem-solving	try to solve problems	try to solve problems in online teams
Reflective	reflect on activities	review e-portfolios of learning activities
Simulation	interact with a simulated tool	study science in a virtual world

Table 1. Learning methods and technology-based examples (based on work by Sharples, 2019)

The Internet has opened up many new ways of working with other people around the world.

Enabling Nature of Technology

Many of today's learners have access to increasingly powerful and affordable handheld computing devices. These include smartphones, fitness trackers and games consoles. They can share, interact and immerse themselves online with others through the use of social networks, augmented reality and virtual environments. They can also create identities and resources that potentially have a worldwide audience enabled by the Internet (Scanlon et al., 2013). These technologies offer six ways of augmenting existing pedagogic practices (Crook et al., 2008; Sharples et al., 2015).

1. **CONNECTIVITY:** The Internet has opened up many new ways of working with other people around the world. It offers a wide range of tools that can support networked, collaborative and conversational approaches to learning.
2. **EXTENSION:** Technology supports extended learning, connecting learning experiences across locations, times, devices and social settings. It offers new tools for creative exploration of the world and provides increasing opportunities to connect learning outside the classroom with learning inside the classroom.
3. **INQUIRY:** Students with access to a smartphone have access to an array of built-in sensors that enable them to measure, interrogate, analyse and record their environment. Technology provides them with new means and structures for organising data, new reference sources, and new tools that can be used to investigate this information space. The Internet supports citizen inquiry, enabling members of the public to propose and engage in scientific investigations that

involve the collection and analysis of data on a worldwide scale.

4. **PERSONALISATION:** Interactions with technology generate sets of data that can potentially be used to enable learners to understand and develop their aptitudes and skills. These data sets may also be used to create personalised paths through educational content.
5. **PUBLICATION:** Learners are no longer restricted to a limited local audience. They can use digital tools and the Internet to engage in authentic tasks that connect their learning with experiences outside the classroom. They can also share their work with a worldwide audience by publishing their creations or their findings.
6. **SCALE:** Education can now be delivered at scale through massive open online courses (MOOCs). When these scaled-up courses make use of social networking and learning through conversations, interactions become richer as learners around the world share ideas and perspectives.

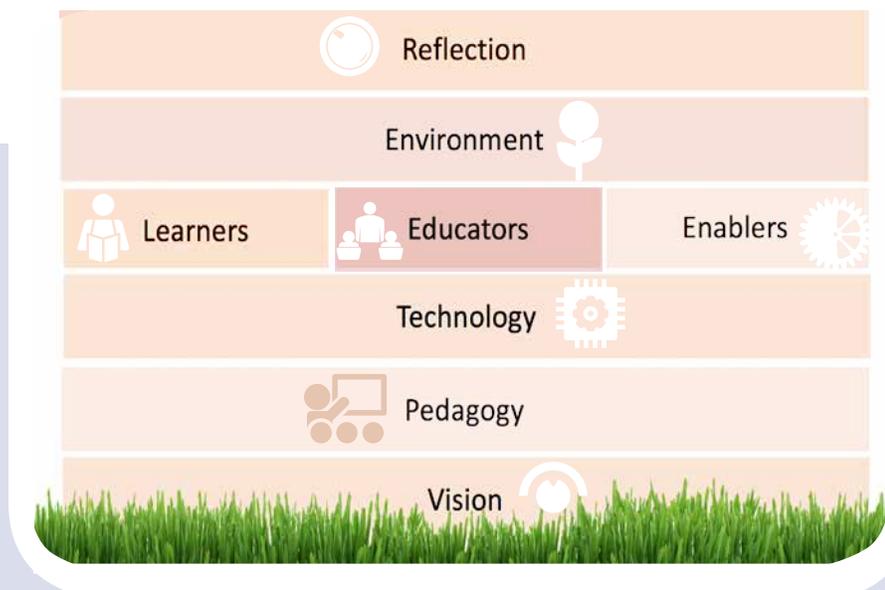


Figure 1. The building blocks of a successful TEL innovation.



What Makes a Successful TEL Innovation?

To make use of the ways in which technology can extend pedagogic practice, it is important to be aware of the building blocks of a successful TEL innovation (Scanlon et al., 2013), as shown in Figure 1.

The building block that forms the foundation of any successful TEL innovation is the vision that drives it. What is the innovation designed to achieve? The focus is not on the technology but on opening up opportunities and improving teaching and learning. A vision describes an achievable and desirable end state. Examples of visions include: “Learners engage enthusiastically with science learning,” “Pupils are able to connect learning outside the classroom with learning inside the classroom” and “Students collaborate successfully with students in other countries”.

Once you have a vision of the future, pedagogy and technology are the next building blocks to put in place. Decide on the approaches to learning and teaching that will help to achieve that vision (Table 1 offers some examples) and consider which technologies will support those approaches. You may, at this point, find that this is not a TEL innovation because it can be implemented using readily available tools such as pens, paper and conversations. If it is a TEL innovation, the next building blocks to consider are the sets of people involved.

Think about the skills your learners and educators will need in order to use the technology. Are they likely to be enthusiastic or resistant? Will they need training? If so, who will provide it? Take into account the enablers whose support will be needed. The managers who approve funding and infrastructure and who develop the policies that block or encourage innovations. The support staff responsible for installing and upgrading software, who install, connect, and maintain hardware. The parents, carers, or wider community who may be sources of support or resistance.

Now consider those groups of people again — this time, looking into the future. Successful innovations are likely to result in enduring changes to practice. Will teachers and learners be enthusiastic once the novelty is gone? Will additional funding or changes to infrastructure be required? Will the need for technical support increase as the hardware and software age? If your innovation requires input from the wider community, will they continue to engage?

Identifying potential problems while planning an innovation makes them easier to address than when work is under way. This stage of development can involve interactions with different groups, identifying and addressing potential problems, discussing possible improvements and engaging the people who will be crucial to the success of the innovation. These conversations also provide opportunities to discuss the next building block of successful innovation: the environment in which the proposed innovation will take place.

Simple issues can block innovative practices. The field trip location has limited Internet access. Another group is using all the available laptops. The devices aren't charged. Parental consent is required before images can be shared online. Planning and preparation can remove obstacles such as these, enabling your TEL innovation to proceed successfully.

Technology is used to find and select projects, to collect and analyse data, and to interact with other participants.

The final building block is reflection. Has this innovation supported progress towards the original vision? Does that vision need to be updated? Are all the building blocks of innovation firmly in place, or is extra work needed so that the innovation can achieve its full potential and go on to be incorporated within standard practice?

INNOVATION 1: Flipped Classroom

The flipped classroom approach is possible when learners have access to digital devices and the Internet at home. Instead of receiving instruction in the classroom and being asked to put their learning into practice as homework, the process is reversed. Students watch video lectures as homework. These videos may be specially prepared for them, or their teacher may select content from the open educational resources (OER) that are freely available online. This approach allows students to progress at their own pace, replaying content they find challenging, and pausing if they need to take notes. Afterwards, in class, they have opportunities to discuss what they learned and to explore further with the expert guidance of their teacher.

This is more than a different approach to delivering content. Students have increased control of when and where they learn; classrooms become more flexible environments, where students engage in active learning and group work.

INNOVATION 2: Place-Based Learning

Place-based learning takes students outside the classroom, providing opportunities to spark their curiosity and investigate their environment. It offers a way for them to make connections between the ideas in their textbooks and the practical issues and challenges that their local communities face. Learning outside the classroom has always been possible, but the use of location-aware

technologies, such as smartphones, adds a new dimension. Sharing images and joint approaches to tasks makes local collaboration easier to initiate and manage. Mobile devices can be used to find locations; to collect, store and visualise data; and to connect learning inside and outside the classroom. Learners can prepare for an activity in one location, carry it out in another and reflect on it in a third. They can also use technology to find, access or create resources connected with a specific place. Some places — historic sites, museums and environmental centres, for example — provide information at specific locations that can be viewed online at those points or overlaid on the environment using augmented reality.

INNOVATION 3: Citizen Science

Citizen science involves members of the public in inquiry and the discovery of new scientific knowledge. These projects use the scientific method, including systematic observation and the formulation and testing of hypotheses. Citizen science projects run locally, nationally and internationally. They are open to everyone, and all participants use the same protocol so that data can be





combined to produce valid and reliable results. Technology is used to find and select projects, to collect and analyse data, and to interact with other participants. Some citizen science projects limit participants to the collection or analysis of data, while others encourage the public to develop their own inquiries that they can work on with others.

INNOVATION 4: Computational Thinking

Every area of the curriculum has its own set of skills and its own way of understanding the world. As students learn to program computers, they develop a set of problem-solving skills that not only are useful when working with computers but also can be applied in any situation.

Computational thinking is a way of structuring any problem so that it can be solved. This way of thinking can be taught as part of science, mathematics, design technology or in other settings. It is unusual as a TEL innovation because it has roots in technology but does not require the use of technology.

Computational thinking breaks large problems down into ones that are smaller and more manageable (decomposition). It finds ways in which these smaller problems are similar to ones that have been solved in the past (pattern recognition). It recognises and sets aside unimportant details (abstraction). It identifies the steps that will be necessary to solve the problem (algorithms). Once these steps have been tried, it improves and refines them (debugging).

These steps can be used when developing a computer game or programming a simple robot. They are equally helpful when planning a celebration meal, diagnosing an illness, or developing a theatrical performance. Computational thinking not only provides a way of approaching problems — it also prompts learners to develop a set of skills that they will use in other subject areas: questioning, connecting, abstracting, experimenting and iterating.

INNOVATION 5: Bring Your Own Devices (BYOD)

One view of mobile devices is that they disrupt classrooms and lessons. “Bring your own devices” takes the opposite view and uses students’ mobile technologies to increase learning opportunities. It recognises that some or all students are likely to have a set of sophisticated tools in their pockets. Their mobile devices will have cameras and microphones that they already use on a regular basis and that can be used to collect images, video and audio. They are less likely to be aware of the sensors built into their smartphones. These include accelerometers, and tools that can record noise levels, light, humidity and temperature. In effect, any student with a smartphone has access to a scientific toolkit that can be used to collect data and perform experiments in any location. Social networking tools can be used to support collaboration; students probably already use these when working on their homework. Learners can use their own devices to access a wide range of resources, to collaborate with others, to access expert opinions and to share their work with a wide audience. This approach must be managed carefully, particularly since not all students have access to these devices. However, the approach has the advantage that students are able to understand how tools they use routinely outside the classroom can be used to support their learning

Reflection and Evaluation

- A successful TEL innovation will have a positive effect on learners, so it is important to include an evaluation as part of the process of reflecting on its implementation. This evaluation can be related to the ABC of learning gains (Rogaten et al., 2019), which covers affective, behavioural and cognitive changes.
- Affective learning gains are associated with a positive change in attitude. Learners may become more confident or motivated. If they were originally over-confident, their expectations will become more realistic.
- Behavioural learning gains are more focused on skills than on knowledge. They include skills related to studying, team work and leadership.

- Cognitive learning gains relate to developments in knowledge, understanding and cognitive abilities.
- One way of assessing learning gains is to interview learners — either individually or in small groups — about what they learned. Another approach is to test or survey them both before and after introducing the innovation, to identify measurable shifts in knowledge or skills.

Conclusions

Successful innovations in TEL are motivated by a vision of what is to be achieved in the future. This vision may be related to potential gains in terms of affect, behaviour or cognition. Examples include: “Next term, learners will be so engaged that they initiate their own inquiries,” “All our students will have the skills to solve a range of different problems” and “Every pupil will know what the scientific method is and will be able to apply it.” Achieving this vision may involve innovative use of products, processes or organisational structures. Any innovation that is introduced will be guided by pedagogy, using approaches based on understandings of how humans learn and how they are motivated to learn.

Pedagogy and vision underpin successful TEL innovation, but other building blocks are needed. Technologies are selected and employed to support the pedagogical approach. Educators, learners and enablers are all taken into consideration. They are involved in developing, implementing and maintaining the innovation. Contextual factors such as funding and infrastructure are taken into account. Finally, evaluation is an important part of the process. It forms part of a reflective stage that can lead to developments and improvements, so the TEL innovations that persist are those that have been shown to improve learning and teaching.

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PEDAGOGICAL INNOVATIONS FOR TECHNOLOGY-ENABLED LEARNING

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 Commonwealth of Learning, 2019

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