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New (and Old) Technologies for Learning: Innovation and Educational Growth

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Abstract
In this chapter I take a retrospective look at the use of technologies for learning, and learning in in schools in particular, through the technological developments of last century into the first two decades of the 21st Century. There are two main sections to my argument. The first is that we should learn from the lessons of the past, both from what has and, perhaps more importantly, what has not been successful before. The second is that the evidence from research clearly shows that it is the pedagogy surrounding the use of technology, and the skills of the teacher or learning technologist in designing, supporting and enabling learners to interact productively which makes the difference in terms of successful learning. *How* we use technology is usually more important than *which* digital technology we choose. One way to understand this is to think of teaching and learning settings as ecologies. These grow and change over time and digital devices have to adapt to survive in different settings. Some technologies become successfully embedded, such as interactive whiteboards in schools or virtual learning environments in Universities, so find their 'niche' and flourish and develop, although the reasons they are successful and their role in the ecology may not improve learning outcomes. It is only by understanding the systemic nature of learning environments that we can design effective digital technologies and innovative tools for teaching and learning. In a final section I briefly look at a recent attempt to design a learning space, SynergyNet, using multi-touch technologies, which supports both group collaboration and the teacher's pedagogical 'momentum' by using the concept of digital and pedagogical 'flow'.

Key words: digital technologies; technology design; teaching and learning; learning ecology

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Overview

In this chapter I take a retrospective look at the use of technologies for learning, and learning in schools in particular, through the technological[1] developments of last century into the first two decades of the 21st Century. There are two main branches to the argument. The first is that we should learn from the lessons of the past, both from what has and, perhaps more importantly, what has *not* been successful before. Second, the evidence from research clearly shows that it is the pedagogy surrounding the use of technology, and the skills of the teacher or learning technologist in designing, supporting and enabling learners to interact productively which makes the difference in terms of successful learning. How we use a technology is usually more important than which digital technology we choose.

The ecology of technology

One way to understand the challenge of using digital technologies for learning is to think of teaching and learning settings as ecologies. These grow and change over time, they evolve, and digital devices have to adapt (or be adapted) to survive in these different settings as the conditions and environments change. Some digital technologies have become successfully embedded, such as interactive whiteboards in schools or virtual learning environments in Universities, so find their 'niche' and flourish and develop. Of course, the reasons they are successful and their role in the ecology may not actually improve student outcomes. Other influences are as or even more powerful than the goal of successful learning. Administrative demands constrain the design and use of virtual learning environments (Passey & Higgins, 2015). The necessity for individual recognition and accreditation structures assessment, to the point where now the last extended

[1] In this paper I use the term 'technology' to mean an artefact designed and created for a specific purpose, like a pencil for writing or a car for transporting people. An 'educational technology' is one designed and used for teaching and learning, such as a blackboard or a textbook. A digital technology is one of many computer-based technologies where information is stored in digital form; this makes is more easily storable, replicable and transformable. A cassette tape recorder is a technology, but not a digital one. A recording app on a mobile phone in today's world produces a digital file which can easily be copied, edited and distributed across other digital devices and technologies.

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handwritten text most young people will compose will be in an examination setting, as for the rest of their lives they will use digital devices to write and edit, both for work and for themselves.

Most new technologies find the teaching and learning environment too challenging to survive. They flourish for a short time, but then disappear and fade from memory. What happened to the overhead projector, with its rolls of transparent acetate and coloured pens? Or the teaching machines of the 1960s? Or the integrated learning systems of the 1990s? They have become extinct, like the dinosaur or the dodo and no longer have a presence in the educational ecology. But in the same way that understanding evolution in biology helps us understand the pressures on the global ecology, so understanding the educational ecology can help us understand the evolution and application of digital technologies for teaching and learning.

Some examples of educational technologies are successful examples of 'exaptation' where the features of a tool acquire a function for which the technology was not originally developed or designed. One of the oldest classroom 'technologies', the blackboard, is a good example of this. The story is that in the early 1800s, James Pillans, the rector of the Old High School in Edinburgh, in Scotland, invented the first blackboard. He was frustrated with trying to explain the geography of different countries to his pupils in small groups so he tiled a section of the classroom wall with the slates his children used to do their work. This created a large display surface which could be written on with chalk for whole class teaching (he is credited with the use of coloured chalks for this purpose too: Bentham, 1816: p 91). A series of single slates were 'co-opted' to create a large blackboard, as George Baron did when teaching mathematics at West Point Academy with "a standing slate" (Albree, Arney & Rickey, 2000: p11). This co-option or 'exaptation' is not unusual in education, as creative teachers solve the some of the pedagogic or didactic problems that they face. The impact of this particular example, the blackboard, was a transformative educational technology which quickly became embedded in the global educational ecology over the next 50 years such that it was a familiar feature in almost all classrooms. Over the

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next hundred years or so the blackboard evolved very little only small changes of material to from chalk to gypsum and with 'greenboards' using low glare porcelain paint from the 1930s, and whiteboards with erasable marker pens in the 1960s. This was until the arrival of electronic or interactive whiteboard in school classrooms at the end of the last century (Moseley et al. 1999: 2.1). It is instructive to consider that this technology was a solution to a challenging teaching and learning problem of its time. Teaching individuals and small groups was considered inefficient, whereas whole class presentation, explanation and demonstration could save the teacher time and improve the efficiency of explanation, demonstration and whole class questioning and interaction. This is something we should bear in mind as instruction and demonstration are often denigrated as old-fashioned and teacher-centred, yet 200 years ago they formed the basis of a pedagogical revolution enabling mass education. In 1811, when chalk and talk was invented, it was such a radically successful solution it was adopted in almost every classroom.

PowerPoint provides another good example of co-option or exaptation. Of course the software can be used by the teacher to present in a similar way to the original design and intention for business use. However, it is also used creatively by teachers to design learning portfolios where pupils store and comment on their achievements individually, or to create talking storybooks with animation and sound, or games with automatic timing feedback for whole class use. It is only by understanding the *systemic* nature of learning environments that we can design effective digital technologies and innovative tools for teaching and learning.

A short history of educational technology: nihil sub sole novum?

Is it helpful, first of all, to look back and to review broadly the effect of new technologies on learning. This next section therefore considers both the historic developments and the predictions about the impact of major communication technologies on education during the last century. This serves as a basis to understand the current enthusiasm and energy for the adoption of digital technologies for 21st Century learning or to revolutionise language teaching in particular. My argument is that these perspectives, as analogies, may help us understand our current educational and technological context.

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My first example is from the emergence of film and the technology of moving pictures or the future envisaged with the emergence of the motion picture, and its predicted impact on education. In July 1913 The New York Dramatic Mirror recounted Thomas Edison's vision for schooling:

> "Books," declared the inventor with decision, "will soon be obsolete in the public schools. Scholars will be instructed through the eye. It is possible to teach every branch of human knowledge with the motion picture. Our school system will be completely changed inside of ten years."

Radio similarly captured the imagination of visionaries in the 1920s and 1930s. In 1926, the educationalist and historian J. C. Stobart wrote a memo, while working for the recently founded BBC, advocating a "wireless university" (Kember 2007, p. 35). In April 1935 Short Wave Craft reported that, Professor C. C. Clark at New York University had conducted a class from his home using shortwave radio. Because the radio was two-way, Professor Clark was able to take questions from the class[2].

The predictions for radio were quickly complemented with exploration of the potential of television and the experimental television technology of the time meant that viewers had to listen to their radio in order to hear the broadcast, as the audio and pictures couldn't be broadcast together. Research was conducted into the potential of television in schools in the 1950s (Levin & Hines, 2003), but it wasn't until the early 1960s that this technology became integral teaching and learning when proposals for a "University of the Air" for adult education evolved into the founding of the Open University in the UK in 1964 (Kember, 2007).

Some of the technological developments were influenced not just by emerging technologies but were also shaped by contemporary learning theories. In the 1960s

[2] http://www.smithsonianmag.com/history/predictions-for-educational-tv-in-the-1930s-107574983/

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language laboratories, with their carels, tape-recorders and headphones emphasised the role of practice and feedback, similar to the programmed instruction models conceptualised by B.F. Skinner[3] a decade earlier. The 1950s and 1960s in particular saw a number of future classrooms predicted with robot teachers or automated push-button machines to provide tailored and efficient education for the individual or class, perhaps reflecting these theoretical perspectives. Today we are more influenced by social learning theories, but the lack the evidence of the predictive validity of these theories in terms of educational impact should encourage us to test the value of these theories in practice through evaluation and not adopt social technological tools, such as blogs or wikis, without be clear how their affordances relate to teaching and learning possibilities.

So what does the research say?

The role of technology for learning remains an important contemporary issue with debates about the effects of technology on our society, the implications of quick and easy online access to information for knowledge and learning and the impact of technology on young people's social, emotional and physical well-being all frequently in the news. It is therefore important to take stock of what we know about the impact of digital technology on teaching and learning from what we have learned over the last fifty years.

The main approach used to evaluate the impact of technology on teaching and learning in schools has been where learners' progress or attainment across a range of tested outcomes has been correlated with the quantity or quality of technology which was available or which they experienced at school or home. At this very general level, computer use makes very little difference to students' achievement. An association between high ICT use and higher student attainment in primary schools was reported in a UK study funded by their Teacher Training Agency study (Moseley *et al.* 1999, p 82). Here however the research team believed that more effective teachers (and more effective schools) tended to use more innovative approaches, or chose to use the ICT resources that they had more appropriately,

[3] See, for example, http://www.youtube.com/watch?v=jTH3ob1IRFo

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rather than that the technology itself was the *cause* of the differences in student performance. Fuchs and Woessmann's (2004) analysis of this link between provision and performance based on the Programme for International Student Assessment (PISA) data supports this interpretation that the link is a correlation and not causal.

The Organisation for Economic Co-operation and Development's (OECD) more detailed analysis of Programme for International Student Assessment (PISA) data indicates a complex picture of association between student performance in school, their access to computers at home and at school together with frequency of use which varies from country to country (OECD, 2006, p 51-66). Here the research found that students who used computers the *most* extensively tended to perform slightly *worse* on average than those with more moderate usage. Overall the analysis suggests that the linkage may not be a simple causal one, nor necessarily a simple linear association. There may be a limit to the amount of technology which is beneficial (for an extended presentation of this argument, see Higgins, Xiao & Katsipataki, 2012).

Caused by, or associated with?

In findings from experimental and quasi-experimental research studies, where gains in knowledge or understanding for groups of students using ICT has been compared with gains for groups learning the same content without technology, results again tend to show positive benefits for ICT. Again these reviews typically conclude that technology has a positive and measurable effect on learning. Most of these reviews do not, however, consider the effects *comparatively*. By far the majority of researched educational interventions have a positive impact, but the relative impact is not usually considered. When a comparative view is taken technology interventions appear to be less beneficial (Sipe & Curlette, 1997[4]).

[4] For an more recent overview of the relative benefits of different educational approaches see: http://educationendowmentfoundation.org.uk/toolkit/ .

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Taken together, the correlational and experimental evidence does not offer a convincing case for the *general* impact of digital technologies on learning outcomes with serious questions about the nature of the evidence base. It may be the case, of course, that digital technologies do have an impact on learning, but that this is not apparent when looking at attainment (as measured by performance in academic tests), or that it is particularly beneficial for certain groups or learners. It is therefore important to identify more precisely and articulate more clearly where and the use of digital technologies is beneficial (Schacter & Fagano, 1999; cf OECD, 2006, p. 69).

Phases of adoption

A further question relates to the phases of adoption of digital technologies. The basis for this is more tentative and draws on a personal interpretation of trends over time. There appears to be a pattern of impact of ICT or digital technologies where, in the early stages, there is a high level of enthusiasm, supported by either anecdotal or qualitative accounts of its benefits, such as with integrated learning systems or interactive whiteboards. At the next stage, as the technology and teaching approaches develop and evolve, these effects are investigated more rigorously. At this stage a mixed message appears with different studies finding different effects or levels of effect (see for example, Parr and Fung's (2000) retrospective analysis of Integrated Learning Systems or Higgins, Beauchamp and Miller's (2007) review of interactive whiteboards). It is rare for further studies to be conducted once a technology has become fully embedded, as interest tends to focus on the new and emerging, so the question of overall impact tends to remain elusive.

If this is the case, there may, of course, be different explanations. We know, for example, that it is difficult to scale-up innovation without a dilution of the effect (Cronbach *et al.* 1980; Raudenbush, 2008). It may also be that early adopters (Rogers, 2003;) tend to tackle particular pedagogical issues or challenges in the early stages, but then the focus shifts to the adoption of the particular technology, without it being chosen as a solution to a specific teaching and learning issue (I'm thinking here of Rogers' 'early' and 'late majority'). At

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this point the technology may be the same, but the pedagogical aims and intentions are different, and this may explain a reduction in effectiveness.

With innovation, its new, but is it better?

Where this difference may also be important is in what the technology *replaces*. Technology is not introduced into a vacuum. As schools and teachers introduce technology they stop doing something else. When teachers choose to adopt technology themselves they often do it as part of a process of inquiry (Somekh, 2007) and it replaces or displaces some problematic practice; when it is adopted for its own sake on a tide of popularity or mandated by policy, its displaces or replaces other teaching and learning activities which may have been as (or more) effective. At this point in the adoption cycle we do not see any educational improvement. An ecological view of adoption is therefore needed, where the justification of technology adoption is a relative one (Zhao & Frank, 2003). It should replace less effective practices as part of a more effective or more efficient teaching and learning context. As yet we do not have the tools to enable us to support these decisions (Underwood & Dillon, 2004). (Again, for further discussion of this argument see Higgins, Xiao & Katsipataki, 2012.)

Overall, the challenge of assessing the impact is more acute than ever. The rise in technologies and the range of ways that they can be used in diverse educational settings across the spectrum of learners, coupled with the pace of change of technology make the task ever more demanding. The focus must shift from the technologies themselves to the pedagogies of use, and the analysis of general impact to the specific differences that digital technologies make to teaching and learning contexts and interactions with regard to particular learners. The quantity of technology use is not the key factor to student learning. "How much" matters when only when "what and how" are identified (Lei & Zhao, 2007).

Global trends: a move towards increasing skepticism?

In the UK, we have been at the forefront of investment in technology in schools in particular, from the Microelectronics Education Programme in the 1980s and the

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development of the BBC Micro (Thorne, 1987), experimentation with software like Integrated Learning Systems (Parr & Fung, 2000) and Talking Books (Underwood & Underwood, 1998) in the 1990s, and then in the first decade of the 21st Century the promotion of technologies like Interactive Whiteboards (Higgins, Beauchamp & Miller, 2007) and Virtual Learning Platforms (Passey & Higgins, 2013). All of these can be characterised by initial enthusiasm for a technology, often shared by practitioners and students in the classroom, then a search for evidence of effectiveness, followed by a refocussing on a newer technology emerging on the horizon. I think of this as a series of breaking waves of optimism, increasing in height as each approaches the shore. Then, as the wave breaks and rushes up the beach we try to estimate whether the tide is coming in or going out in terms of educational improvement. Next, the initial enthusiasm recedes, like the wave running back down the beach and we look out to sea at the next wave approaching the beach. As I stand on the technological 'shore' at this point in time, I can hear the crash of iPads, tablets and MOOCs as the wave of enthusiasm for this technology breaks on the beach, and I can make out the swell of coding, Clouds, serious games and learning analytics as these waves approach. How does the new enthusiasm for coding differ from students' encounters with LOGO and BASIC in the 1980s? Are learning goals the same in a game as in other contexts, or does winning the 'game' change engagement? With learning analytics is the data designed to be useful or just easy to collect?

Old wine in new technological bottles?

This perhaps casts too negative a view of technology and its impact on teaching and learning. Each technology has not necessarily been washed away by the next, but some find their own particular niche and have become embedded. This might be for a number of reasons, not necessarily educational. They may provide as effective an approach, but be more cost-effective or simply more popular. Blackboards and slates were cheap and reusable. We still use printed books, a technology introduced to Europe by Gutenberg in about 1439, so long ago now that we perhaps no longer think of moveable type and books as a technology. There are alternative media for reading, but we will have to see to what extent electronic books *replace* bound printed versions in the remainder of this century or

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simply become an alternative form. The underlying technology of the written (or digitised) word however shows no sign of being replaced, despite enthusiasm for the multi-modal presentation of information. Overall, however, the impact of technology on teaching and learning has not been as great as initially predicted (Cuban, 1986), nor is there clear and consistent evidence of positive effects on learners' outcomes (Higgins, Xiao & Katsipataki, 2012). If my argument is correct, then it is for teachers and learners to identify how new and emerging digital technologies can help them to teach and to learn more effectively or more efficiently that before. This way each successive technology will only replace or displace less effective practices. We cannot afford to wait until each new piece of digital equipment has been thoroughly tested and evaluated before introducing it. This simply takes too long and a newer version or more innovative technology will appear. What we can do is look at what the existing evidence tells us in terms of teaching and learning, both about technology and about effective approaches to teaching and learning more broadly, and make some predictions about how a new approach might be better than something we already do, then test and critically evaluate the potential improvement so that we can be reasonably sure we are not just adopting technology for technology's sake.

Designing for solutions: designing for learning

In this final section, I will briefly look at a recent attempt to design a learning space, SynergyNet, using multi-touch technologies, which supports both group collaboration and the teacher's lesson 'momentum' by using the concept of digital and pedagogical 'flow' (Mercier & Higgins, 2013). One of the problems we sought to solve was the interruption of the teacher's and students' activity by having to switch between whole class, group and individual stages of a lesson when digital technology was involved. We therefore aimed to develop a networked environment where digital resources could be moved from the teacher's whiteboard, to student desks and even individual tablets is necessary, preserving the form as we as the content, so that a task could be flicked from one digital surface to another and equally importantly worked on and changed on each device on which it was displayed. One group's work could be shared with the whole class, then used to replace the other's work to take the learning forward effectively. Our argument is that digital devices

often interrupt the pedagogic flow of the lesson, important to the teacher as she or he needs flow to maintain both engagement and order and helps to build up the momentum of a lesson. Digital flow can support this and ease transitions between student and teacher-centred phases of the lesson (Higgins, Mercier, Burd & Joyce-Gibbons, 2012). We argue strongly that too great a reliance on either student-centred or teacher-centred approaches leads to a critical imbalance in the teaching and learning ecology. One of the things we have learned from the dominance of the blackboard is that some educational solutions can evolve in time to be greater problems than the issues they sought to overcome. We should seek digital solutions to teaching and learning problems so as to increase the probability they will be helpful for learning. Understanding innovation as contributing to educational growth is the first step.

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