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CHAPTER 25

Digital technology integration

Michael Phillips

Introduction

This chapter challenges you to examine the often uncritical debates about the use of digital technologies in classrooms. Many of the articles written about digital technology tend to do so in unrealistic terms, providing 'state of the art' examples that suggest educational technology has the potential to completely transform schools for the better. For some time, discussions about educational uses of digital technologies have highlighted the potential benefits of emerging digital technologies for teachers who choose to adopt these tools as part of their classroom practice. Teachers, predominantly from developed western nations, have been seduced to take up these technologies through advertising campaigns sponsored by digital hardware and software companies, influenced by aspirational statements made by political parties and compelled to achieve standards set by teacher registration organisations. These occasions have reinforced the assumption that digital technologies have the capacity to enhance society generally and teaching and learning more specifically.

In contrast, Neil Selwyn's (2010) critique of schools and schooling in the digital age summarises the tenor of both popular and academic perceptions of digital educational technology stating 'many general discussions of the digital age tend to be informed by a notion that the development of digital technology represents a distinctively new and improved set of social arrangements in relation to preceding "pre-digital" times' (p. 7). While commenting on the differences in pre- and post-digital social arrangements, Selwyn (2010) provides a particular insight, highlighting Woolgar's (2002) inherent 'implication that something new, different, and (usually) better is happening' (p. 3). This 'pervasive sense of leaving the past

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behind' (Murdock, 2004, p. 20) is evident in the work of many researchers in the field of educational technology who are 'driven by an underlying belief that digital technologies are – in some way – capable of improving education' (Selwyn, 2011, p. 713). As such, a great deal of effort has been invested in researching the learning potential of new or emerging technologies with many of these research studies focusing on 'state of the art' or high level uses of digital technologies in classrooms (for example, Becker, 2001; Cuban, 2001, 2004; Donald, 2002; Ertmer, 1999; Hattie, 2009; Mumtaz, 2000; Parisot, 1995; Somekh, 2008; Straub, 2009).

Investigations into state of the art or exemplar instances of digital technologies in education have prompted educational technology researchers such as Connell (2007) to claim that 'we are on the verge of profound change' (p. 7), or, as Laurillard (2008) more wryly observed, 'education is on the brink of being transformed through learning technologies; however, it has been on that brink for some decades now' (p. 1). Laurillard's observation highlights the fact that state of the art case studies, which are the basis of many investigations, remain somewhat distinct from the more prosaic, or what Selwyn (2008) calls, the 'state of the actual'. In other words, there is a disjuncture between the rhetoric and the reality or a division between the potential and the practise when it comes to the educational uses of digital technologies in teaching and learning. A number of researchers examining teachers' pedagogical adoption of information and communication technologies (ICT) in schools claim that technology integration is not happening, happening too slowly or happening with little or no effect on student learning.

In contrast to these polarised views, the 'state of the actual' may be somewhat different and exist somewhere between these perspectives. In many schools, you can find teachers using particular digital technologies as part of their teaching practice, yet in the same school, you could find other teachers using completely different software or hardware in contrasting ways. Likewise, you may find other teachers in the same school who are using little or no digital technology in their classrooms. It is comparatively simple to identify which teachers are and are not using digital technology in their classrooms but it is much harder to determine which teachers are using digital technology *effectively* as part of their classroom practice.

CRITICAL QUESTION

How do we know when digital technologies are being used most effectively in classrooms?

This chapter examines this critical question from a range of different perspectives that illustrate both the complexity of this issue and the different ways in which you might consider the use of digital technologies in your own practice and that of your colleagues. While all of these approaches are contested by various

commentators and have weaknesses (some highlighted in this chapter), they also have their strengths, not least in revealing the complexity of the issue.

While reading the following sections, try not only to keep in mind the critical question presented above, but also consider that adherence to only one perspective on technology integration may be fraught with difficulties and challenges as you might only understand one part of a complex series of inter-connected factors.

Barriers to technology adoption

Many researchers have attempted to find out why teachers' use of digital technologies varies so widely. This work has led to the development of a range of theoretical perspectives that attempt to understand the reasons for teachers' (non) use of digital technologies in their classrooms. These perspectives have considered a range of factors which may contribute to teachers' (non)use of digital technologies with Ertmer (1999) categorising these as first- and second-order barriers.

Studies that have examined first-order barriers have provided some helpful guidance about overcoming comparatively simple obstacles which have been 'described as being extrinsic to teachers and include lack of access to computers and software, insufficient time to plan instruction, and inadequate technical and administrative support' (Ertmer, 1999, p. 48). These first-order barriers 'have since been eliminated in the majority of schools' (Ertmer et al., 2012, p. 423) by procuring additional hardware and software along with further professional development opportunities. Despite reducing the impact of many first-order barriers in schools, effective technology integration remains a challenge for many teachers (for example, Howard, Chan & Caputi, 2014; O'Bannon & Thomas, 2014; Waight, Chiu & Whitford, 2014) and this has resulted in an increased focus on more complex second-order barriers.

In contrast to first-order barriers, 'second-order barriers are intrinsic to teachers and include beliefs about teaching, beliefs about computers [and] established classroom practices' (Ertmer, 1999, p. 48). Studies considering second-order barriers can contribute a more critical perspective than those merely examining comparatively simplistic first-order barriers as investigations given that second-order factors consider the 'fundamental' and 'personal' (Ertmer, 1999, p. 48) barriers to effective integration of digital technologies in teachers' classroom practices.

Understanding the differences between first- and second-order barriers is helpful when considering teachers' technology use as it provides a way for you to begin to refine your focus. In particular, you can now begin to consider whether teachers are faced with school or system wide barriers such as access to sufficient technology or whether the effective use of digital technology is a more personal barrier.

There are a wide variety of approaches that have been developed by researchers in an attempt to understand the ways in which second order barriers can be overcome and digital technologies can be integrated in school classrooms. These include learning theories such as constructivism, behaviourism, cognitivism or connectivism

which have all been used to explain effective use of digital technology; however, the following section will provide a critical understanding of three different perspectives that are often used, sometimes erroneously, to examine teachers' technology integration: Diffusion of Innovations, TPACK and SAMR. These three perspectives have been chosen not only because they are commonly used in schools and professional development settings, but also because they provide three different ways to consider effective technology use. Diffusion of Innovations provides the opportunity to examine effective digital technology use across social systems. TPACK draws attention to the forms of knowledge individual teachers need to effectively integrate digital technologies into their practice while SAMR is a framework that allows you to consider the effectiveness of digital technology use in different classroom activities.

Diffusion of innovations: understanding technology adoption across social systems

The processes shaping and driving the adoption of any new innovation have been of interest to researchers from a wide variety of fields including political science, public health, communications, history and economics as well as education. A number of theoretical approaches have been developed to take into consideration the ways in which social systems influence the adoption or rejection of different innovations. For example, Wenger's (1998) development of the idea of a Community of Practice focuses on the impact of both practice and identity and the way in which ideas and activities are adopted or rejected by different groups of people.

Another perspective that is often used in professional development sessions or discussions related to teachers' use of digital technologies is Rogers' (1962) Diffusion of Innovations. This theory has made substantial contributions to an understanding of how innovations can move through a variety of populations including the ways in which teachers adopt digital technologies (for example, Sahin, 2006). The theory is extensive and cannot be explained in detail here; however, it is useful to note that Rogers proposed a number of characteristics and processes that influence the diffusion of new ideas across a group, and adoption of new ideas by an individual within the group. Rogers argued that diffusion was a result of individuals undergoing a five–step decision-making process leading to the adoption of the new idea or practice. However, he also argued that this is influenced by the kinds of communication channels involved (for example, policy, role modelling) and the degree of sustained time group members are exposed to the idea. In addition, he identified five attributes of an innovation that increased the likelihood of its adoption: relative advantage, compatibility, complexity, trialability and observability. Importantly, he also proposed that within an organisation there are gatekeepers and opinion leaders who influence the adoption of ideas, and that typically adopters fall into one of five categories: innovators, early adopters, early majority, late majority and laggards.

While it may be helpful to understand factors which influence adoption of an innovation such as digital technologies across a broad population, any discussion of population-wide adoption may be problematic since within any population there are individuals or subgroups that do not conform to expectation. For instance, an early adopter of one innovation is not necessarily going to be an early adopter of another (Greenhalgh et al., 2004). This may be seen in schools when a teacher is keen to have the students using iPads to allow for individual, problem-based learning activities to run while the same teacher may not choose to use electronic whiteboards as they do not match with his or her pedagogical aims. The generalised approach evident in broad adoption theories has also been shown to be a challenge when looking at the particular requirements of teachers and their (non)use of digital technologies (for example, Frank, Zhao & Borman, 2004) due to an inherent pro-innovation or pro-adoption bias.

The challenge with a pro-innovation or pro-adoption bias is an underpinning assumption that 'an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected' (Rogers, 2003, p. 106). This problem is evident in models such as Rogers' Diffusion of Innovations and has been recognised for some time (Rogers & Shoemaker, 1971) and yet continues to be a weakness with Rogers' (2003) himself claiming 'not enough has been done to remedy the problem' (p. 106) with subsequent research continuing to report similar problems (for example, Talke & Heidenreich, 2013).

Rogers' theory, and the considerable work that has been done since, has left a persistent legacy in terms of technology innovation in education. Not only is the effective integration of technology often assumed to be a simple matter of engaging teachers in the rather simplistic decision-making process, its inherent pro-adoption mandate has left behind labels such as laggards and resistors that are frequently applied to teachers who are perceived not to be integrating technologies as expected. The emphasis on blaming the individual for a decision not to adopt a practice is in tension with the notion that teachers are professionals who may be making that decision because their learners are best served by that decision. As a consequence, while Diffusion of Innovations and similar theories can provide a useful set of ideas for how we can approach the task of adopting new ideas, and how those ideas can be diffused through an organisation like a school, we need to continue to be critical of the fundamental pro-adoption agenda, wherein it is assumed that new ideas (including new technology practices) are inherently desirable.

TPACK: what knowledge do teachers need to effectively use digital technologies in their classrooms?

In contrast to the social system perspective offered by Rogers' Diffusion of Innovations, some researchers have considered the influence of individual

attributes on digital technology integration into classrooms. For example, Bandura's (1994) work on self-efficacy and Ertmer's (1999) investigation of teachers' beliefs mentioned earlier in the chapter have contributed to our understanding of the influence of individual teachers' traits on effective digital technology integration.

More recently, Mishra and Koehler (2006) have also considered digital technology integration from the perspective of an individual teacher. In doing so, they considered what knowledge teachers require to effectively incorporate digital technologies into their classroom practice. In response, Mishra and Koehler suggested that teachers need to consider the interplay between three forms of knowledge: technological knowledge, pedagogical knowledge and content knowledge (known as TPACK). Moreover, they argued that the most effective use of digital technologies occurs in a classroom when the teacher has a combination of all three forms of knowledge.

Mishra and Koehler (2006) represented their TPACK framework as three overlapping circles, with each circle representing a component of teachers' professional knowledge. This model resulted in seven potential forms of teachers' professional knowledge with the aspirational TPACK positioned at the nexus of these circles.

Furthermore, they represented the context in which teachers acquire their knowledge as a dotted line bounding these different forms of knowledge. While there have been many researchers who have helped to define the different forms of overlapping knowledge represented in the TPACK framework, little attention has been paid to the context in which teachers acquire and put into practice their knowledge. Recent research (Phillips, 2014) using Communities of Practice as a theoretical lens, found that teachers TPACK enactment is influenced by processes of identity development and practice as shown in Figure 25.1.

Despite the comparative simplicity of the model illustrated in Figure 25.1, Mishra and Koehler (2006) acknowledge that 'integrating technology into teaching is not easy' (p. 2). Moreover, they suggest that the numerous variables associated with effective digital technology integration in a teaching and learning context presents teachers with a 'wicked problem'.

Wicked problems are not, as the name might initially suggest, sinister or evil. Instead, wicked problems, as opposed to tame problems, are difficult to describe and 'rely upon elusive political judgement for resolution. (Not 'solution'. Social problems are never solved. At best they are only re-solved over and over again)' (Rittel & Webber, 1973, p. 160). In contrast to the answers provided by scientific or quantifiable models such as Diffusion of Innovations, Mishra and Koehler's use of the term 'wicked problem' to highlight the social considerations involved with teachers' effective integration of digital technology provides an opportunity to examine some second-order barriers notably absent in the pro-adoption biased model discussed earlier in this chapter.

While a great deal of valuable research has contributed to our understanding of the TPACK development of teachers in working different settings, more recent research has begun to examine the intricacies of the second-order barriers influencing the effective TPACK enactment in classrooms. In particular, research into teachers' workplaces has begun to reveal the complexity of TPACK enactment

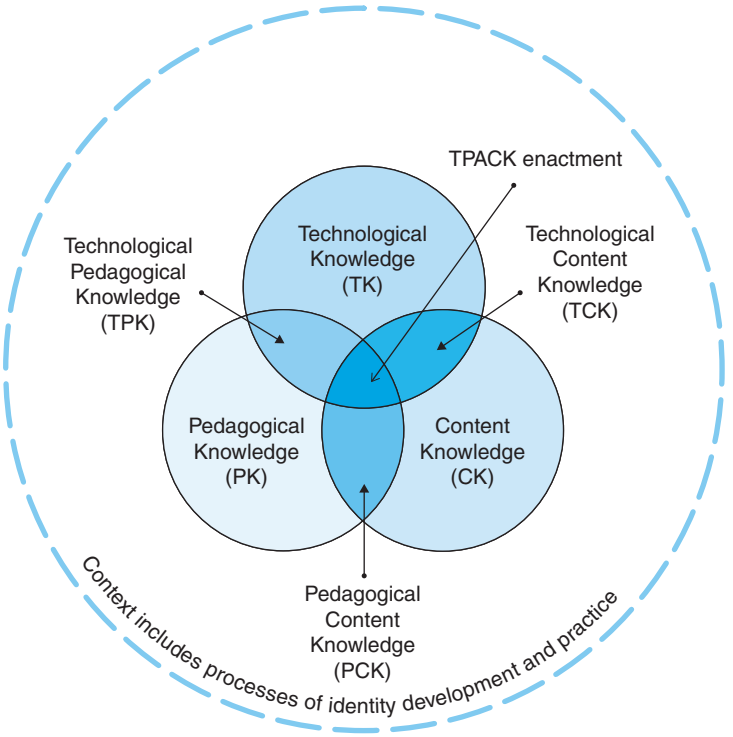

Figure 25.1: . An elaborated representation of TPACK enactment in a Community of Practice (Phillips, 2014)

(Di Blas et al., 2014; Phillips, 2013, 2014; Porras-Hernández & Salinas-Amescua, 2013).

One of the significant findings from investigations into these second-order barriers has been a shift from considerations of the interplay between the different forms of knowledge represented in the TPACK framework to the factors influencing teachers' enactment of their knowledge. While it may be valuable to measure different forms of teachers' TPACK to enhance professional development opportunities, simply measuring their knowledge does not help explain differences in the ways technology is or is not effectively integrated in different settings.

For example, a teacher may effectively integrate digital technologies in a Year 8 Science class using augmented reality and may use augmented reality software to provide students with dynamic models which clearly demonstrate the flow of oxygenated and de-oxygenated blood flow to and from working muscles. However, the same teacher, in the very next lesson with a Year 12 Chemistry class may choose not to use digital technologies at all, instead preferring to work through practice exam questions leading up to an assessment task. It is unlikely that the teacher's TPACK has varied moving from one room to another, but the enactment of TPACK has varied dramatically. Understanding changes in context, such as in this example, can provide opportunities for us to expand our considerations of the factors influencing effective integration of digital technologies beyond simple binary choices of adoption and non-adoption.

This section has introduced TPACK and outlined how this model considers effective technology integration by examining individual teachers' knowledge and practices. While the TPACK framework has been used in hundreds of studies and provides insights not offered by models such as Diffusion of Innovations that consider issues from a social system level, TPACK also has weaknesses. In particular, this section has highlighted that teachers who may be considered to have TPACK in one setting might enact their knowledge in very different ways in another setting; in other words, teachers' practices can look different depending on the students in front of them rather than as a result of changes in their knowledge. As such, some educators find it valuable to evaluate the way digital technologies are used in particular activities in classrooms. The following section introduces a common way in which teachers evaluate the effectiveness of digital technologies used in particular classroom activities.

SAMR: considering different levels of technology integration

A third way of considering the effectiveness of digital technology use is by evaluating the activities that incorporate digital technologies. The implication of the use of this approach is that if we can define what an effective use of technology for learning is, then we can replicate it across different contexts. For instance, if we can define a valid use for iPads then teachers can simply use that idea, or adapt it. There are a variety of ways in which people have approached this desire to define effective technology integration activities, including the use of Bloom's Taxonomy (for example, Eteokleous, 2008; Tomei, 2005), however SAMR is an increasingly popular model of technology integration.

Part of the popularity of this model, originally proposed by Puentedura (2006), is due to its relative simplicity coupled with the inherent assumption that technology can fundamentally redefine the nature of the educational activity. The SAMR model proposes four possible levels of digital technology integration: substitution, augmentation, modification and redefinition. At the simplest level of the SAMR model, substitution occurs when teachers or students use technology as a direct replacement for a non-digital alternative with no functional change. Augmentation extends teachers' and students' use of digital technologies by offering a functional change afforded by the digital tool chosen. These first two levels have been described as enhancement stages. The third and fourth levels have been described as transformative stages where modification or redefinition of learning tasks is made possible by the use of digital technologies.

The model provides teachers with ways in which they can consider how they engage students in differing forms of learning activities. However, by itself, the SAMR model provides little direction to guide teachers in the ways in which they might 'transform' the learning activities in their classrooms.

As a result, the SAMR model has been used in conjunction with other theories in an attempt to provide teachers with ways in which they might apply this model.

For example, Kathy Schrock (2014) believes that teachers 'should be planning for technology tasks, activities and assessments that include both the higher levels of Bloom's Revised Taxonomy and the transformation area of SAMR model' because it is possible to have redefinition tasks that only target the remembering leve,l or creative tasks and assessments that are at an augmentation stage.

While this application of the SAMR model provides some guidance as to the ways in which teachers might structure activities that can be considered as transformative and creative, there continues to be a technologically deterministic aspect to this approach – that simply by designing an activity that incorporates digital technology will contribute to a 'distinctively new and improved set of social arrangements in relation to preceding "pre-digital" times' (Selwyn, 2010, p. 7) reflecting Woolgar's (2002) inherent 'implication that something new, different, and (usually) better is happening' (p. 3).

Concluding comments

Technology integration, or more accurately, the effective integration of technology to improve the processes of teaching or learning, is not easy. There is no consensus or definitive explanation of what technology integration looks like in a classroom, or how it can be achieved. Instead we are left with a series of theories or propositions. This chapter cannot include all of them. Instead, it has touched on three popular frames of reference. Diffusions of Innovations is a somewhat dated theory, but relevant due to its persistent language of adopters/laggards. It tries to explain how innovative practices (including those involving technology) are adopted and adapted (diffused) across systems such as schools. The implication here is that effective technology integration is a function of the system, and can be influenced by changing the relative advantage, compatibility or complexity of the innovation. In contrast TPACK is a theory of personal attributes; the interplay of our expert knowledge within any particular context underlies our effective use of technology in teaching. The implication here is that effective technology integration can be influenced by changing an individual's knowledge or the priority they give it within a specific context. Finally, this chapter briefly describes the relatively recent SAMR framework that tries to define a continuum of technology integration practices, in which effective technology integration is simply a matter of using the technology in ways that cannot be done otherwise. The implication here is that more effective technology integration can be achieved by simply choosing a type of technology activity that is higher on the continuum.

Each of these ways of understanding technology integration needs to be considered critically; they have both strengths and weaknesses. In particular, Diffusion of Innovations can provide helpful understanding of social systems and give us a macro-perspective on the way factors such as complexity, trialability and observability can influence the diffusion of innovations through a population; however, it is unlikely to give insights into an individual teacher's practices. In contrast to the social system perspective offered by Rogers' Diffusion of Innovations perspective, some researchers such as Mishra and Koehler have considered the influence of individual attributes on

digital technology integration into classrooms. While their TPACK framework provides one explanation of the interplay between different forms of knowledge underpinning effective technology integration, it does not help to explain the inclusion of different activities in particular settings. A third way of considering the effectiveness of digital technology use is by evaluating the activities that incorporate digital technologies through models such as SAMR. The assumption here is that if we can define what an effective use of technology for learning is, then we can replicate it across different contexts. However, a weakness of SAMR is a lack of consideration of second-order barriers such as teacher beliefs and the individuality of classrooms, learners and teachers in contrast to the inherent implication that the use of technology will necessarily lead to enhanced learning outcomes for students.

Clearly, there is no single theory, model or framework that, by itself, can explain how you or your school can effectively integrate technologies into the processes of teaching or learning. This chapter has shown that effective technology integration can be understood as a process of change or learning in social systems (including the school institution), individual characteristics and finally understanding of the nature of technologies and how they can be applied in new ways. Adherence to just one perspective of technology integration may be fraught with difficulties and challenges because it might be accompanied by understanding only one part of a complex series of inter-connected factors.

Exploring

In Chapter 23, it was suggested that TPACK cannot be divorced from the perspectives discussed in that chapter. Given the exploration of TPACK in this current chapter, re-consider where TPACK fits and how it might be implicitly represented in the frameworks presented in Chapter 23.

On a professional placement experience, take some time to wander through the corridors of your school over the course of a single period, looking into classrooms and learning spaces you pass. When you see a teacher or students using digital technologies, make notes (using the table below) on your observations in relation to the models of technology integration discussed in this chapter.

Observations	Class 1	Class 2
What kind of space is it? (e.g. classroom/ art studio/ science lab)		
Considering Rogers' Diffusion of Innovations model, where would the teacher be positioned on the distribution curve?		

Observations	Class 1	Class 2
Thinking back to the TPACK model, what evidence can you observe that indicates the types of professional knowledge the teacher is using to guide their classroom integration of technology?		
SAMR describes different levels of technology integration. What level are the activities you can see?		

- How might a teacher's classroom use of digital technologies be evaluated?
- What challenges would you face if trying to evaluate what was occurring in the different classes using the three models?
- Should the focus be on what the teacher intended for students to do with digital technologies or on what the students actually did? Which models of technology integration would be appropriate to use for each of these approaches?
- Why might a teacher choose not to use digital technologies for a particular lesson?
- How can teachers evaluate whether a particular form of technology will match their lesson objectives?What considerations would you take into account when selecting a model to evaluate the effectiveness of technology integration in schools? Compare and contrast your thoughts with others in your class.


Further information and resources on this topic are available at <www.cambridge.edu.au/academic/>

Further reading

Diffusion of Innovations

Rogers, E. (2003). *Diffusion of Innovations* (5th ed.). New York: Free Press.

This is the latest edition of Rogers' work. Since the original edition in 1962, Rogers has continued to develop his theory and this edition presents a revision of the theoretical framework and the research evidence supporting this model of diffusion, as well as introducing new concepts and new theoretical viewpoints. This edition differs from its predecessors in that it takes a much more critical stance in its review and synthesis of 5000 diffusion publications.

TPACK

Mishra, P. & Koehler, M. J. (2006). Technological pedagogical content knowledge: a framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.

This is the seminal work that introduces the TPACK framework and is an essential starting point for anyone who wishes to explore TPACK in more depth. While many works have built on the initial description of TPACK presented in this chapter, Mishra and Koehler's work provides the theoretical foundation for future explorations.

SAMR

Jude, L. T., Kajura, M. A. & Birevu, M. P. (2014). Adoption of the SAMR Model to asses ICT Pedagogical adoption: a case of Makerere University. *International Journal of e-Education, e-Business, e-Management and e-Learning*, 4(2), 106-n/a. doi: http://dx.doi.org/10.7763/IJEEEE.2014.V4.312

This article provides a contemporary application of SAMR in a higher education context and provides pre-service teachers with the opportunity to examine challenges associated with technology adoption that they may be experiencing in their own tertiary studies as well as considering the ways in which similar challenges may be experienced in other educational settings.

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