Enhancing Teachers' Take-up of Digital Content: Factors and Design Principles in Technology Adoption

PROFESSOR
MICHAEL GAFFNEY

Education Services Australia

A merger of curriculum corporation and education.au creative capable connected

Acknowledgements

I am indebted to Craig Ashhurst and Mal Lee for their research assistance in the preparation of this report. Their expert advice and practical insights were much appreciated. Many thanks to the Curriculum Liaison Officers who work with Education Services Australia, and who contributed their knowledge on the take-up of digital content within their jurisdictions. I would also like to express my gratitude to Amanda Roberts, Daniel Hughes and Di Kerr from Education Services Australia for their timely support and counsel in the research and drafting of this report.

About the author

Professor Michael Gaffney is Chair of Educational Leadership at the Australian Catholic University. He has wide experience as a teacher, an education system senior executive, and as researcher, consultant and policy advisor to Australian governments in the areas of education policy and leadership, and curriculum and teaching practices appropriate to 21st-century schooling.

About Education Services Australia

On 1 March 2010, Curriculum Corporation merged with Education.au to form Education Services Australia Ltd, a new, national, not-for-profit ministerial company, delivering innovative, cost-effective services to the Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA) and other education and training bodies.

Executive summary

A large pool of digital content is available for use in Australian schools. While digital curriculum resources have been shown to improve engagement and understanding (Cox et al 2004; Freebody 2005), a number of Australian school education jurisdictions report that many teachers do not yet include digital content in their classroom program (Rowe 2008).

This research was designed to find out what works in helping teachers embed digital curriculum resources into their teaching practice. The research methodology had two components. First, a literature review was undertaken to identify the major findings from recent research and thinking on teacher use of digital curriculum resources and associated technologies in school education, and the factors which are related to such use. Second, a meta-analysis was done to synthesise the findings from the literature review and information from Australian jurisdictions made available by Education Services Australia.

The meta-analysis enabled the development of a model for embedding digital curriculum resources into teachers' pedagogical practice. This model consists of two dimensions: one dealing with the types of factors associated with teacher take-up of digital content; and the other concerned with the characteristics of various stakeholders and the nature of digital curriculum resources (the content) and supporting technology (the tools).

The major finding from this study is that enhancing teacher take-up of digital content is a multi-faceted undertaking. It involves strategic and simultaneous attention to the:

- relevance of the digital curriculum resources
- appropriateness of the technological tools to deliver them
- capability of teachers to use them
- motivation and interest of students to learn with them
- culture of schools to institutionalise their use
- political will and capacity of governments and educational authorities to develop policy to promote and monitor their use
- importance of education systems developing awareness and shared understanding about the value of digital content
- the means by which the actions of governments, education authorities, schools, teachers and students are aligned and integrated through the implementation process to increase teacher use of such resources for the benefit of students.

On the basis of these findings, the following design principles should be considered in supporting teachers to embed digital curriculum resources into their pedagogical practice. These are categorised in terms of the type of factors to which they most closely apply.

1. Contextual factors

1.1 Governments and education authorities have clear goals and policies for adoption.

1.2 The timeline for adoption by governments and education authorities (ie the political timeline) associated with policy development, program delivery and evaluation reflects the timeline for adoption by schools and teachers (ie the educational timeline) associated with finding, assessing relevance, take-up and refinement of the use of digital content.

1.3 Schools have the infrastructure necessary for adoption, including available, suitable and affordable technological tools.

1.4 Teachers and students appreciate the relevance of the digital content and how it relates to the curriculum, and see links to current teaching and learning practices.

2. General change factors

2.1 Leaders in government, education authorities and schools encourage a culture of inquiry and openness to change.

2.2 Government and education authorities provide an appropriate balance of pressure and support for change.

2.3 The capabilities and technical skills of teachers and students are recognised as assets rather than liabilities.

2.4 The technological tools are reliable, useful and aligned with the school culture.

3. Innovation-specific factors

3.1 Digital content is readily accessible, links with the curriculum, and does what it purports to do.

3.2 There is a clear implementation path for adoption and it is linked to whole-school planning.

3.3 Government and education authorities allocate resources strategically and equitably, and have processes to promote and monitor the use of digital content.

3.4 Teachers and students have the resources to use digital content (including access to hardware and software, 'how to' guides, and expert technical and educational support).

4. Systemic factors

4.1 There is awareness and consensus among government, education authorities, school leaders, teachers and students about their philosophy of educational technology and the value of digital content, as well as the means by which the use of such content can benefit students.

4.2 The adoption process is designed and implemented so that the efforts of governments, education authorities, school leaders, teachers and students are aligned (through attention to the contextual, general change, innovation-specific, and systemic factors noted here) to achieve effective integration of digital content into teachers' pedagogical practice.

In light of the findings from this report, I recommend consideration of the above principles and the accompanying Technology Adoption Model – Factors for enhancing teachers' take-up of digital content (see page 20) by Australian schools and education authorities. I trust that these resources will prove useful to Australian schools and education authorities in informing policy to enhance teachers' use of digital curriculum resources for the benefit of all Australian students.

Professor Michael Gaffney
May 2010

Introduction

This research has been undertaken for Education Services Australia. It contains an analysis of factors associated with enhancing teachers' take-up of digital content in their pedagogical practice. It involved:

- conducting a literature review and meta-analysis to identify the major findings from recent research and thinking on teacher use of digital curriculum resources and associated technologies in school education, and the factors which are related to such use
- drawing conclusions about what works to help teachers embed digital curriculum resources into their teaching practice.

This report is intended to support Australian school education jurisdictions in their policy development and service delivery to teachers and students, and increase the use of digital curriculum resources for the benefit of all Australian students.

Research methodology

The methodology for the study was comprised of a literature review, identifying the major findings of existing recent literature and thinking on this topic; and meta-analysis, referencing both the literature review and information from State, Territory, Catholic and Independent school education jurisdictions made available by Education Services Australia.

In analysing the literature, outlining the results and drawing conclusions, particular attention was paid to identifying those factors that do not involve substantial additional investment by jurisdictions. While the quality of the digital curriculum resources available to Australian teachers may well be a factor influencing teacher take-up, a detailed evaluation of resource quality was not in the scope of this report; neither was a detailed examination of the extent of the take-up of digital content and digital pedagogies by teachers.

The methodology for this study sought to overcome some of the limitations in current research methodologies documenting change in teachers' practices mediated by digital technologies (Orlando 2009). The research design was qualitative, using a combination of analysis of research and related literature as well as the collection and analysis of primary data from educational jurisdiction representatives (from requested jurisdictional responses) and teachers (from comments on practitioner list serves). In this way, the study was able to adopt a grounded approach by using the data to identify themes linked to teacher take-up rather than apply a predetermined focus (for example, technology as the central concern) or theoretical perspective (for example, constructivism) to the research problem. The literature review involved identifying and mapping the types of factors which influence teacher take-up against the characteristics of significant players (governments, educational authorities, schools, teachers and students) and the nature of the digital resources and supporting technology.

Rapidly evolving technologies and the influence of the market place on teachers' choices of instructional technology are having profound impacts on the levels of classroom use of digital curriculum resources.

The meta-analysis synthesised key insights from the literature review and information from Australian jurisdictions. The term meta-analysis refers to 'a method designed to increase the reliability of research by combining and analysing the results of all known trials of the same product or experiments on the same subject' (Encarta English Dictionary). In this research study, the meta-analysis was concerned with the identification of recurring themes in the literature. This involved gathering information about the frequency and importance given to particular factors associated with teachers' use of digital content.

The meta-analysis enabled the development of a model for embedding digital curriculum resources into teachers' pedagogical practice. This model is comprised of two dimensions: one dealing with the types of factors associated with teacher use of digital content; the other concerned with the characteristics of various stakeholders and the nature of digital resources and supporting technology. The model provides the basis for policy advice (including a series of design principles categorised by factor type) for the information of jurisdictions.

Research question

What factors influence teachers to embed digital curriculum resources in their pedagogical practice?

In this study the term digital curriculum resources refers to online curriculum content which can be used and customised by teachers in a variety of formats, including interactive multimedia resources, interactive assessment resources, and digital curriculum resources which have been sourced from cultural and scientific institutions and private collections.

Findings

Relevance of digital curriculum resources

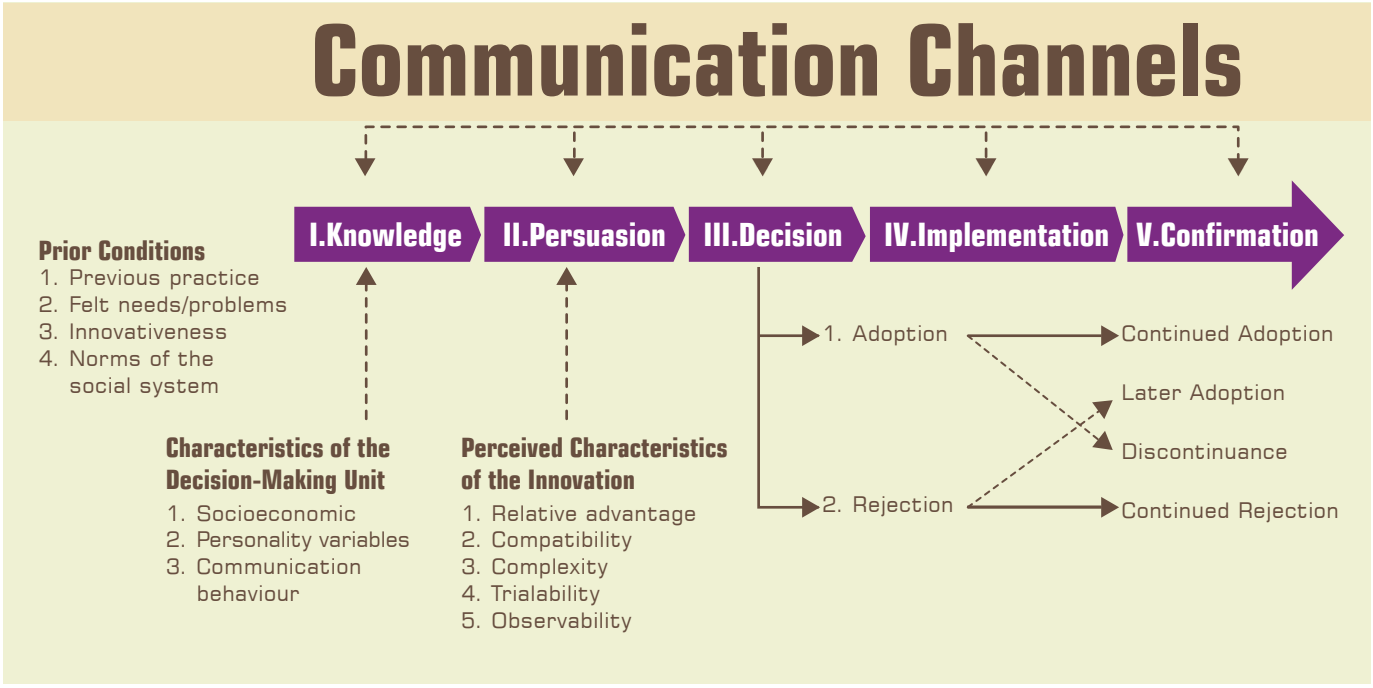
Teachers consider the relevance of digital curriculum resources according to two criteria: the appropriateness of the digital content to the curriculum to be taught; and how the use of a particular digital curriculum resource aligns with their teaching practice (Cuban 2001).

From this perspective, questions of the relevance of digital curriculum resources, appropriateness of digital content, and their acceptance and use by teachers are not straightforward. In fact, research by Dikbas Torun et al (2008) indicates that teachers engage in a complex decision-making process in considering the adoption of technological innovations, as indicated in Figure 1. Their decisions are influenced by their personality, experience, professional knowledge, relationships and context; and their assessments of the relevance (and value) of digital curriculum resources are influenced by any combination of these.

Strijker & Collis (2006) examine the issue of the relevance of a digital curriculum resource in deciding about its reuse. Their study based on research in university, corporate learning, and military contexts identified a set of dimensions to help decision makers develop strategies for reuse of Learning Objects. The following dimensions were identified: cultures within the context, learning scenarios, incentives for reuse, work processes and how Learning Objects are stored. The context for each dimension can be more 'systems-oriented' (based on technical specifications, organisational rules and procedures) or 'personal-oriented' (focusing on human interaction, personal needs and values) depending on the situation. They concluded that:

> **For each context the strategy for reuse may be different because the cultures within the context can differ. The learning scenarios, the incentives for reuse, the work processes, and how Learning Objects are stored do not have to be the same (Strijker & Collis 2006, page 94).**

Figure 1 Stages of teacher decision making in adoption of technological innovation.



Source: Dikbas Torun, E, Kocak Usluel, Y, & Ilgaz, H (2008). Teachers' Adoption of Laptops in the Stages of Innovation Decision Process. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications.

In Strijker & Collis's (2006) terms, questions of relevance and reuse of digital curriculum resources (such as Learning Objects) are best resolved through consideration of the context and the degree to which a particular resource is oriented towards personal as compared with system characteristics and needs. Put simply, if the dimensional profile of a digital resource does not align with one's preferred personal or system orientation then it is unlikely to be reused – or taken up in the first place!

The implication is that innovations must be presented in terms that are meaningful to potential users. This supports consistent findings from research into the diffusion of innovations where the rate of adoption increases significantly when innovations possess the following characteristics: simplicity, compatibility with existing methods and techniques, and relative advantage in comparison with these established methods and techniques (Rogers 1962).

In light of this discussion, the following issues should be considered when assessing the relevance of digital curriculum resources. First, what level of awareness do teachers have of the meaning and variety of digital curriculum resources (and related terms such as 'digital content' and 'Learning Objects')? And second, what is the nature and degree of consensus among teachers, software designers and education policy makers relating to the orientation, relevance and use of digital content? Implications arising from these issues suggest a need for genuine collaboration (involving teachers, software designers and education policy makers) in the production of digital curriculum resources, and strategic promotion and dissemination of information by teachers about the nature and advantages of using those resources.

Appropriateness of technological tools

The availability, suitability and cost of technological tools play an integral role in teachers' take-up of digital content. Rapidly evolving technologies and the influence of the market place on teachers' choices of instructional technology are having profound impacts on the levels of classroom use of digital curriculum resources.

Lee & Winzenried (2009) highlight this point in noting successive trends associated with the 'discovery' and promotion of various examples of instructional technologies, from radio, television, overhead projectors and videos to personal computers – all of which at some point were

predicted to revolutionise teaching, and subsequently did not! They explain that much of the effort over the second half of the 20th century was directed at getting teachers to use these discrete technologies in their teaching (with the personal computer being merely one of the latest examples).

Despite the hype and investment, Lee & Winzenried (2009) argue that successive efforts faltered because each wave of technological innovation failed to take account of the dominant features of teaching practice, namely those associated with whole-group instruction. They suggest that it was not until relatively recent times that teachers and students had a practical way of presenting digital resources to a whole-class group. Lee & Winzenried explain that it was only through the 'triple convergence' that began around 2000 (Friedman 2006) that the data projector and the interactive whiteboard (IWB) reached a level of maturity and a price point that such schools could afford to use them for whole-class teaching. In this context, the triple convergence related most especially to the advent of more powerful and reliable web-enabled platforms for collaboration – through the internet, email and digital convergence. This research of Lee & Winzenried reveals how path-finding schools took advantage of these new forms of 'whole of class digital technology' and were able to secure total staff and student adoption of the technology within a relatively short timeframe compared with previous efforts. The factors identified as responsible for this unusually successful 'whole of school' use of the technology were: an appropriate technology for whole-class teaching; a critical mass of IWBs; school leadership which is focused on the teaching rather than the technology; and a comprehensive and integrated implementation strategy (Lee & Winzenried 2009).

Similar research undertaken by Buchan et al (2008) highlights the relatively recent pedagogical shifts taking place as a consequence of increasingly sophisticated technologies. Their work in the higher education sphere emphasises the need for learning designs to be more formally and pedagogically grounded, and for associated multimedia production to be more closely linked with the institutional planning. One implication of this research is that as the demand for, and power of technological tools grows, so too does the need to ensure the use of those tools is pedagogically sound and strategically planned.

A further implication from this research and that of Lee & Winzenried (2009) is that teachers' acceptance is a vital ingredient; and that such acceptance is reliant on how the technology links with their current practice. In the case of IWBs, the technology provides a bridge to existing teaching practice, together with a large-screen digital convergence facility which is able to support teachers in new forms of whole-class teaching. The following vignettes illustrate how some teachers are using Learning Objects with IWBs:

> We have been using Learning Objects for several years, both [The] Learning Federation and other online resources. Teachers readily use them with IWBs, and we place links to LOs from Scootle into our Moodle inquiry units. The awkward process of copying a password-enabled direct link from Scootle into IWB files or Moodle is a hurdle, but we do it!

> I think the Learning Objects are a fantastic resource but they have a difficult, convoluted navigation system. After using the Learning Objects with a class, the children want to be able to revisit them. To make the process easier, I have spent countless hours capturing screen shots of the first screen of LOs and then making a web page with annotations for our intranet. Unfortunately, I only managed to complete the Maths LOs and some of the Science … One day I hope to complete the job but time is the problem.

These illustrations emphasise the need for readily accessible and reliable supporting technology and the importance of professional initiative, technical expertise and timely support in using that technology for the delivery of digital content.

Allied with the introduction of IWBs, Lee & Winzenried (2009) describe the move from discrete instructional technologies to an integrated suite of technologies, supported by increasingly sophisticated interactive multimedia software (for example, Smart-Notes, ActivStudio and Easiteach). They also note the continuing impact of technology companies upon the take-up, success and ultimate superseding of instructional technologies. Drawing upon the five-stage Emerging Technologies Hype Cycle (2006) developed by Gartner Consulting, Lee & Winzenried predict that if a digital resource does not secure significant client usage, its lifespan will be short and it will be superseded by more attractive offerings regardless of who develops the item – be it government (for example, Becta), industry (for example, Promethean Planet) or the international networked community (for example, GeoGebra).

When considering the issue of teacher take-up of digital content, the importance of having accessible, useful and reliable technological tools to deliver such content should not be underestimated (Law 2009b). These tools need to support the desired teaching and learning culture within the school, and teachers need technical support and other resources to use them in timely and effective ways (Lee & Gaffney 2008; Mumtaz 2000).

ClickView – an appropriate tool?

ClickView is one example of a technological tool used to support the delivery of digital content. It has a Learning Objects Manager facility which allows the importation of objects from a DVD/CD or from a LORAX proxy server. Once in the ClickView system, the objects can be located, unzipped and presented from the ClickView Player. They can also be taken home by staff and students on portable USB media using the ClickView School Bag facility. On the other hand, licence fees associated with becoming a 'ClickView school', together with firewall and internet gateway rules on some school/education authority networks which block a school's direct access to a LORAX server, may be potential barriers in using this tool for the delivery of digital content.

When considering the appropriateness of technological tools like ClickView, systemic factors relating to alignment and integration of the various educational, technical and bureaucratic components associated with delivery come to the fore. Where there is awareness and consensus among the stakeholders in the classroom, school and central office about the value of digital content, there is more likely to be a coherent implementation strategy and supporting infrastructure. Unfortunately, the converse is also true as the following vignette demonstrates:

> **The thing that puts staff off is that at least half the time using objects is a wasted lesson because the Department servers don't cope and are so slow to load (or simply don't load) that the kids sit there twiddling their thumbs.**
>
> **The Learning Objects are great but as long as technology isn't up to par they are simply a mirage in the teaching desert.**

Available, suitable, affordable and reliable supporting technology is vital for enhancing teacher's take-up of digital content. Moreover, any assessment of the appropriateness of technological tools must involve the competent judgement and discretion of teachers (Zhao 2007).

Teacher capability

Teachers' knowledge, skills and attitudes developed through their personal experience of schooling as students, their pre-service training, their participation in subsequent professional development and their day-to-day work and interactions with colleagues and other members of their school communities, have a significant influence over their classroom use of digital technologies (Bingimlas 2009; Mulkeen 2003).

Encouraging teacher take-up of digital content involves more than developing their competency in the technical aspects. In fact, educational research has been somewhat naïve in presuming that the right combination of training, technology and opportunity for 'reflective practice' will somehow result in high levels of teacher take-up (Bore & Wright 2009; Ward 2008). The situations in which teachers find themselves are far more complex than that. This is because teaching and learning with new digital technologies represents a 'wicked problem': that is, a problem that includes a large number of complex variables – all of which are dynamic, contextually bound, interdependent and, consequently, very difficult to solve (Borko et al 2009). Such circumstances call for teachers that can deal with complex issues, demonstrate self-direction and creativity, and continue to learn; and who, from an organisational viewpoint, are provided with the necessary degree of discretion to develop and practice those professional qualities (Bore & Wright 2009).

For these reasons, the term 'capabilities' is more appropriate in describing teachers' potential and facility in using digital technologies. Capabilities are qualities which integrate knowledge, skills and attitudes in such a way that they can be used appropriately and effectively in new and changing circumstances (Stephenson, as cited in Duignan, 2006, page 120).

The central importance of the teacher in the use of technology was first identified by Cuban (1986;2001) when he wrote about teachers as 'gatekeepers' and the level of discretion they have in deciding whether or not to use technology in their classroom – no matter how strongly this might be mandated (Tyack & Cuban 1995).

Writing almost 25 years ago, at the dawn of the 'age of personal computing', Cuban criticised the historic failure of schools, education authorities and technology companies to consult teachers in the design and choice of technology. He argued that enhanced take-up of digital technologies would only result from adopting technologies that could work within the everyday realities of the classroom. He wrote that:

> Since the mid nineteenth century the classroom has become home to a succession of technologies (eg, textbook, chalkboard, radio, film, and television) … Yet the teacher has been singled out as inflexibly resistant to 'modern' technology, stubbornly engaging in a closed-door policy toward using new mechanical and automated instructional aids … Seldom did investigators try to adopt a teacher's perspective or appreciate the duality of continuity and change that marked both schools and classrooms (Cuban 1986, pages 2, 6).

Developing teacher capability involves attention to both intrinsic and extrinsic dimensions. The intrinsic dimension is concerned with understanding and appreciating the teachers' world and the multi-dimensional nature of their work (Orlando 2009), and how to identify changes in their thinking and behaviour (Lim et al 2008); while the extrinsic dimension is focused on the external influences on the teacher (Levin & Wadmany 2006).

Examples of the intrinsic conditions required for teachers to consider using technology are that the teacher must believe that using technology will support the achievement of higher level goals while not causing disturbances to the achievement of other higher level goals; and she or he has or will have sufficient ability and resources to use technology (Zhao & Cziko 2001; Runyon & Semich 2002). On the other hand, examples of extrinsic factors include availability of technical and funding support, and computer access (Mumtaz 2000).

Levin & Wadmany (2006, page 4) link the intrinsic and extrinsic dimensions of teacher capability in terms of a developmental continuum as follows:

> At one end … lie the external influences on the teacher, and at the other end … are the teacher's internal behaviors, in other words, her self-regulated, reflective behaviors. Between the two extremes lies the teacher's dialogue with colleagues and students, which the teacher perceived as an important factor in helping them to implement the considerable innovation required by the project.

Similarly, Mumtaz (2000) refers to interlocking intrinsic and extrinsic, human and technical factors that affect teachers' take-up of technology: the teacher, the resources and the school. These are illustrated by teachers having the experience and time to become comfortable with the technology, ready access to hardware and software and technical support, and school leaders as well as organisational arrangements that help to create a culture that promotes the use of the technology.

In a similar vein, the Becta (2004) study highlights the interconnectedness of human and technical variables, and the importance of teachers perceiving the educational value in the technology and having the confidence to use that technology before they will use it every day in their teaching. Their research found that teachers will use digital teaching resources when there is time to become comfortable with the technology, and appropriate training and development, as well as ongoing professional and technical support are provided.

One means of developing teacher capability that recognises the presence of the intrinsic and extrinsic dimensions, and the importance of human and technical components, has been proposed by Mishra & Koehler (2006). They have developed a conceptual framework for teacher use of educational technology by building on the formulation of 'pedagogical content knowledge' by Shulman (1986; 1987). The framework is designed to capture the essential qualities of teacher knowledge required for integrating technology into their teaching, while addressing the complex, multi-faceted and situated nature of this knowledge. Mishra & Koehler argue that effective teacher use of technology requires the development of a complex, situated form of knowledge that they call Technological Pedagogical Content Knowledge (TPCK, also known as TPACK). In doing so, they posit the complex roles of, and interplay among, three main components of learning environments: content, pedagogy and technology. TPCK includes:

> an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what concepts are difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and develop new epistemologies or strengthen old ones (Mishra & Koehler 2006, pages 1,017–18).

An illustration of the TPCK framework and the capabilities that teachers bring to bear is evident in the following commentary from a secondary teacher:

> I use Learning Objects (LOs) in my virtual classrooms on Blackboard [a learning management system]. My students access them at home, or in class time if we have access to computers (which is frequently difficult to arrange). Although I have a portable projector (personal) and laptop (departmental), I seldom show LOs in class since I teach in a number of rooms and find my school's wireless network unreliable. The rooms also have major glare problems and setting up difficulties which I find time-wasting in a 70-minute lesson. [On the other hand] my students enjoy being able to revisit the LOs in their own time in the virtual classroom.

In this example, the teacher is demonstrating pedagogical content knowledge – by orchestrating a conducive learning environment for her students to learn selected material with the support of appropriate technological tools, as well as the capability to work with the complex 'technological givens' creatively and in a self-directed manner.

Finger & Jamieson-Proctor (2010) have elaborated on the work of Mishra & Koehler (2006) through constructing

a model which maps stages of teacher and school development using Technological Pedagogical Content Knowledge (TPCK) features. Their work highlights the connections between the development of individual teacher capability, the developmental stage that the school has reached in its use of digital technologies and networked modes of operation, and the design of teachers' work and working conditions. One implication of this research is that teacher take-up of digital curriculum resources (and use of digital technologies more generally) is not only a consequence of their individual professional capability, but is also closely associated with their school's cultural characteristics, especially its openness to change and its approach to planning in relation to digital technologies.

A further implication of the research is how teachers believe and use digital technologies to enhance student learning and engagement, and how this capability can be developed (Borko et al 2009; Mishra & Koehler 2006; Finger & Jamieson-Proctor 2010).

Student interest and motivation

Student attitudes, concerns and experience with technology in general and as an instructional tool are important determinants in the successful take-up of digital content by teachers (Mishra & Koehler 2006; Groff & Mouza 2008).

Moyle (2010) provides insights into how students use technologies for learning, and communicating with each other inside and outside of school, and reflects upon the implications of these practices for students and schools. There is much that educators do not know about how students use technologies. In noting that emerging technologies, such as Web 2.0 social networking, provide new opportunities, she advises that the 'ubiquity of technologies and the robustness of young people's abilities to communicate and collaborate presents challenges for educators and stakeholders about how they conceive of schools' (Moyle 2010, page 39).

While much has been written about the generational and digital divide between teachers and students (Prentsky 2001), other research highlights that similarity in approach and perspective between teachers and their students supports creative and effective use of digital technologies. For example, Levin & Wadmany (2006) have found that teachers' and students' level of comfort with uncertainty is directly related to their ability to use technology creatively.

Research by Mumtaz (2000) supports this view in reporting that teachers who successfully used digital technologies have a positive attitude towards ICT, emphasise student choice rather than teacher direction, and encourage students' empowerment as learners rather than as recipients of instruction. Teachers who adopt this approach are not only more likely to use digital technologies creatively, but also to encourage higher levels of student interest and motivation (Lee & Gaffney 2008).

This point is illustrated by Victory (2008, page 24) in his case study of Luther College, Croydon, Victoria where he explains that:

> The school has allowed every student to be an administrator on their own computer. In short this means they have complete control over the machine and its functions, its uses and what they access with the computer. They can effectively wipe the computer and then restore it themselves the next day.

He readily admits that:

> This is an approach that many school leaders, parents and politicians would find frightening; [but he goes on to explain that] while the school has most sophisticated monitoring software … the most valuable thing that a school can do is provide students with a moral compass and, in doing so, encourage students to make good decisions about what they access and what they do with their computer (Victory 2008, page 24).

This case study highlights the importance of 'meeting the students' mindset' and the point that the crucial element of any technological innovation is the development of the human being – not the implementation of more powerful technology.

The research by Vallance (2008) takes this work a step further by describing the strategic actions, adapted from ISTE (2007) that need to be taken up in Japanese schools to provide students with the opportunities to learn and

prosper in a digital age. These actions are described in terms of four constructs of student development: *thinking*, *learning*, *creativity* and *communication*.

Precisely how these and similar listings of student development and use of digital technologies are translated to classroom settings remains a key challenge. One approach to meeting this challenge is suggested by Zhao (2007) in his study of teachers' perspectives of technology integration. The approach is summarised in Figure 2 below.

The continuum proposed by Zhao (2007) describes how the roles of the teacher, the student, and the technology change as one moves from teacher-centred to student-centred teaching; and how these changes are reflected in the technological tools which are used and how the classroom is organised.

Such approaches can provide a useful, explicit basis upon which to consider why and how teachers would use digital technologies (including digital curriculum resources) in their teaching. Since they focus on the teaching–learning relationship, they raise questions about how teachers view the roles and responsibilities of students in learning, and how their teaching practices and use of digital technologies align with those views to enhance their students' interest and motivation to learn.

Figure 2 Continuum of technology use in the social studies classroom.

	Teacher-centred	Stuctured Inquiry	Teacher–Student Negotiated	Student-centred
Teacher Role	Use technology to present information and lecture	Create worksheets and research activities using computers and teach prepackaged materials	Set specific requirements and assign topics	Facilitator and collaborator
Student Role	Store information, complete worksheets	Use technology to obtain information or do research	Explore a variety of information using teacher-provided resources	Student-led instruction and self-decided inquiry
Technology Role	Facilitate presentation	Provide content knowledge in place of or supplemental to textbook materials	Provide tool for accessing content information, organising information and/or presenting findings	Provide tools for inquiry and presentation
Technology Tools Used	PowerPoint	Word Processor, Excel, WebQuest, games, internet resources	Internet and web-based resources, PowerPoint, Timeline	Combination of tools: internet, overhead projector, PowerPoint, Microsoft Publisher, Inspiration, Timeline, digital/video camera
Classroom Organisation	Independent work	Individual learning	Individual or collaborative learning	Individual or collaborative learning and teaching

Source: Zhao 2007, page 322.

School culture and leadership

The shared values and guiding beliefs of a school community, and the ways in which such understandings are reflected in the day-to-day life and organisation of schools have considerable bearing on how and the extent to which change occurs in schools. This combination of beliefs and practices which comprise a school's culture is notoriously resistant to innovation, particularly when changes call for people to think, act and organise their work differently. In such circumstances, change is only possible where there is effective and strategic leadership (Fullan 2005). Effective leaders shape the culture of their schools in ways that foster an openness to change for the benefit of students. These leaders recognise and address the range of human, educational, organisational and technological factors influencing the change process (Lee & Gaffney 2008).

Research studies on factors affecting the implementation of digital technology, as an example of significant educational change, similarly emphasise the need for informed and strategic leadership at school and educational authority levels (Lee et al 2010; Keane 2008). In addition, research in this area also commonly lists factors such as teacher acceptance, training and professional development; available, suitable, affordable, useable and reliable technology (including network infrastructure); appropriate digital content and software; clear implementation strategy; and sufficient time and other resources to sustain the change process (Lee & Winzenried 2009; Venezky & Davis 2002; Condie & Munro 2007).

In the day-to-day life of some schools, the factors identified in the literature are evidenced in a variety of counterproductive ways – from the abdication of leadership by school executive and the overt control of the infrastructure by the IT department, to constraints on teachers' time to learn and engage with the technology brought about by pressures to cover the curriculum and teach to the test (Lee & Gaffney 2008). On the other hand, whole-school valuing of digital technologies and associated curriculum resources, especially by the school executive, makes a difference. Collaborative planning, peer mentoring, and strategic decisions to allocate resources to specialist staffing (for example, teacher librarians) and professional development have been shown to pay dividends (Holkner et al 2008; Lee & Gaffney 2008).

School cultures that promote adoption of new and engaging teaching and learning practices and the use of digital technologies to support them are more likely have school leaders who are aware of the benefits and complexities of technologies and the need to plan, staff and structure their schools accordingly (Mulkeen 2003; Kopcha 2010; Victory 2008). And teachers in these schools are more likely to use digital technologies (including digital curriculum resources) in their teaching.

Political will and capacity of governments and educational authorities

Widespread and sustained educational change will not occur without the political resources of governments and education authorities to provide an appropriate combination of pressure and support (Barber & Mourshed 2007; Fullan 2005). This point is reflected in the OECD report by Venezky & Davis (2002) that highlights the roles that government and education authorities play in supporting the take-up of digital technologies in schools. Their findings from case studies across 23 countries emphasise the importance of schools and educational authorities adopting comprehensive strategic planning approaches, involving the development and promotion of clear goals and policy; targeted and equitable resource allocation; and ongoing monitoring of the program delivery.

The importance of an appropriately contextualised, comprehensive long-term implementation strategy was similarly highlighted in the review undertaken for the European Commission by Balanskat et al (2006) into the use and impact of digital technologies in European schools. The review emphasised the importance of coordinated leadership between the school and educational authority level, adequate finance, and a suitable infrastructure (including reliable broadband access for schools, and ready access to technology in all classrooms).

The importance of informed and strategic action by government and educational authorities is evidenced by the role that the British Educational Communications and Technology Agency (Becta) played in supporting

> *Widespread and sustained educational change will not occur without the political resources of governments and education authorities to provide an appropriate combination of pressure and support.*

educational technology innovation in the United Kingdom. The annual reviews conducted by Becta (2005–2009) provided a comprehensive examination of the progress made on technology initiatives in UK schools. The reviews present findings from longitudinal studies into the use of varied digital technologies (for example, personal computers, IWBs, digital resources, learning platforms and the network infrastructure); and provide policy advice on the implications of technological change, the impact of market forces on the school technology and related issues that require particular attention. For example, while the UK has mandated the use of virtual learning environments (VLEs) or learning platforms, its most recent report indicated that only ten per cent of teachers are using them regularly.

The Becta reviews have been used for policy development by government and by related educational statutory bodies and agencies including Ofsted and the National College for School Leadership. For example, when the degree of teacher acceptance and use of IWBs and the associated digital resources placed strains on the network infrastructure (as evidenced by the growth from five per cent of classrooms with IWBs in 2002 to over 75 per cent in 2009), the British Government moved nationally to enhance the network's carrying capacity.

A related aspect of Becta's work has been in providing research advice to the British Government in its drive to develop interactive multimedia (IMM) software and its use by teachers. The government strategy was twofold. First, the government, through the former Department for Children, Schools and Families outsourced the development of IMM software with the aim of spawning the UK software industry. Contracts were made with the smaller niche companies (for example, The Big Bus) as well as the larger established publishers (Cambridge University Press). Second, the government made funds available to schools in the form of eLCs (electronic Learning Credits) to spend on multimedia resources.

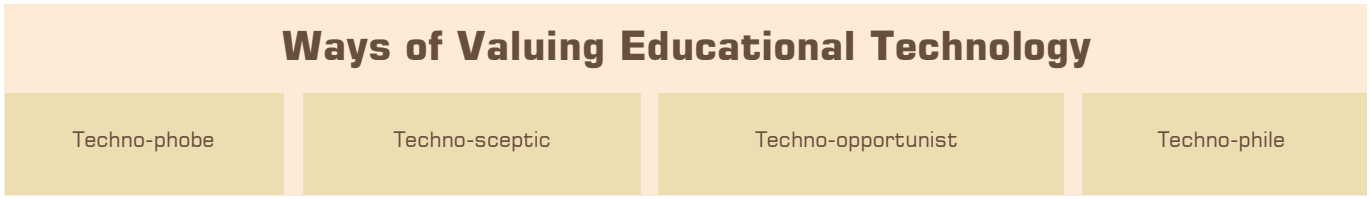
There are several implications for governments and education authorities for enhancing teacher take-up of digital content arising from the strategy adopted in Britain and the findings cited from research studies undertaken for the OECD and the European Commission. First, there is value in the government supporting the development of appropriate digital resources and the consequent IMM industry. Second, governments need to ensure that there are suitable, available and affordable technological tools (for example, IWBs and broadband connectivity) to deliver the digital content. Third, government provision of school and teacher incentives to use digital content through the use of eLCs is worthy of further investigation. Fourth, the political timeframes of government need to reflect the educational timeframe of schools. This means allowing enough time for the adoption of emerging technologies in order to realise its policy goals. In this respect, it is worth noting that the British Government strategy commenced in the late 1990s, and through the support of Becta, consistently took a long-term, research-based approach. Finally, government not only has an accountability role in monitoring specific innovations but also a systemic role in examining how related areas of policy are aligned and integrated with those innovations. This also involves observing broader trends and opinions regarding the use and development of technology.

Systemic awareness and consensus about educational technology

The value that people place on educational technology is a consequence of their experience and knowledge of it and how these aspects shape their philosophy about its use. One way of conceptualising the different ways in which people value educational technology is through the continuum presented in Figure 3. It draws upon the early work of Rogers (1962) in describing the diffusion of innovation across various groups of consumers from the *laggards* to the *early adopters*.

At one end, we have the 'techno-phobe', who lacks the capacity and/or will to engage with new technologies. The 'techno-sceptic' is prepared to engage with technology but is wary of its short-term and/or long-term benefits. Moving further along, we have the 'techno-opportunist' who is willing and able to select, use and adapt particular aspects of new technologies to achieve specific outcomes. At the other extreme, there is the 'techno-phile' – the person who believes that all technology is good and that innovation in technology is, by definition, always something to be encouraged!

Figure 3 Typology of ways of valuing educational technology.



In considering the range of players and stakeholders involved in enhancing teacher take-up of digital content – from teachers, students, parents and school leaders, to ICT companies, education bureaucrats and ministerial advisors – one can readily appreciate the diversity of awareness and views about educational technology and the challenge of reaching a workable consensus about its value and use.

Because of this variety, there is a need for education systems (comprising schools, central offices and governance bodies) to increase the level of awareness and agreement among their constituents about the value of digital content and the means by which the actions of the various stakeholders (governments, education authorities, ICT companies, schools, teachers and students) can be aligned and integrated to increase teacher use of such resources for the benefit of students. In essence, this is a two-part challenge: one part dealing with *perspective* (ie the education philosophy and value which individuals and groups associate with technology); the other relating to *process* (ie the means by which the various components of development, implementation, monitoring and evaluation of technology are aligned and integrated).

The writings of some noted philosophers are helpful in tackling the first part of this systemic challenge. One example from the 'techno-sceptic' part of the continuum is from French philosopher Jacques Ellul (1964,1968). Ellul wrote about the threat to human freedom created by modern technology. He warned that modern-day humans generally held the technological society as sacred and were becoming increasingly focused on the drive for more efficient techniques in every field of human activity (Lovekin 1977). As a consequence, he argued that technology, rather than being subservient to humanity, was in fact subordinating the natural world and forcing human beings to adapt to it. Ellul explained that the major problem of such trends for school education was that people begin to question those things which do little to advance their financial and technical state, thereby narrowing the curriculum and the learning opportunities open to students. A contrasting perspective is provided by Alvin Toffler (1970). Arguing from the 'techno-phile' end of the spectrum, Toffler sees technology as providing individuals with opportunity for greater freedom and more choice (Lovekin 1977).

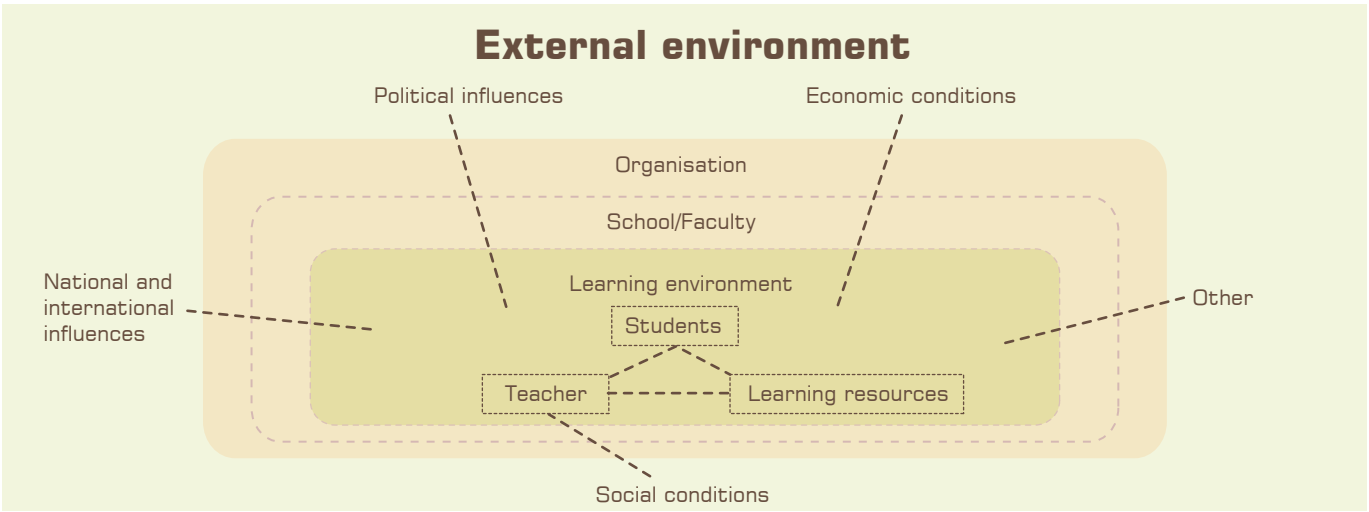
This diversity of perspectives about the value of technology remains a crucial element in considering the issue of teacher take-up of digital content. As a deeply human endeavour, teaching involves more than the application of 'efficient techniques' (Ellul 1964). At the same time, the use of technology can increase the choices of learning pathways available to students. Therefore, teachers, education bureaucrats and policy makers all need to consider the value of technology, why it is being used, and how they can take others' perspectives into account, and thereby successfully blend calls for efficient as well as personalised teaching and learning.

Mumtaz (2000) recognised this need to blend the range of human and technological variables to enhance teacher usage of digital resources. In his study, factors found to influence teachers' classroom use of ICT included: access to resources; quality of software and hardware; ease of use; incentives to change; support and collegiality in their school; school and national policies; commitment to professional learning; and background in formal computer training. His review found that teachers' beliefs about teaching and learning with ICT are necessary but not sufficient for them to successfully use digital technologies. He found that successful implementation of ICT needs to address three interlocking frameworks for change – the teacher, the school, and policy makers – and the perspectives that the players and stakeholders in each sphere bring to bear.

Buchan (2008) presents a similar perspective on the need to build awareness and consensus among stakeholders in her model depicting the relationship between the learning environment, the organisation and the external environment, shown in Figure 4.

The model developed by Buchan (2008) illustrates the complex nature and varied influences on the relationships among students, teachers, school leaders, educational authority officers and government. Despite this complexity, it is essential that stakeholders at every level in the system take the opportunity to engage in policy discussions about the value of digital technologies and how best these resources can be used to benefit students (Bore & Wright 2009). This leads to the second dimension of systemic challenge: building alignment and integration in implication processes.

Figure 4 The relationship between the learning environment, the organisation and the external environment.



Source: Buchan 2008.

Systemic alignment and integration in implementation

The second area of systemic challenge relates to issues of process, and how to ensure the necessary alignment to bring about effective integration of digital content into teachers' classroom practice. For the purpose of this discussion, the terms alignment and integration are defined as follows:

> **alignment:** the correct position or positioning of different components with respect to each other or something else, so that they perform properly, ie to achieve integration.
>
> **integration:** a combination of parts or objects that work together well, the process of coordinating separate elements into a balanced whole or producing compatible behaviour.
>
> (Encarta Dictionary: English [UK])

The implementation processes for teachers to successfully embed the use of digital curriculum resources into their teaching practice need to be aligned and integrated. The following overview of the research literature on the factors influencing implementation highlights the patterns of supporting and constraining influences and the need for strategic and clear intent, communication and coordination of effort.

For example, Franklin's (2007) study of teachers' use of computers for instructional purposes identified the following factors influencing teacher use: leadership by school and district administrators; access and availability of hardware and software; incentives to participate in professional development; personnel, technical and pedagogical support; external constraints over which teachers have little or no control; and teacher philosophy and professional preparation.

In a similar vein, Bingimlas's (2009) meta-analysis of the literature on perceived barriers to technology integration in science education indicated that while teachers had a strong desire to integrate ICT into education, the major barriers were a lack of time, confidence, competence, and access to resources. Consequently, he recommends that reliable, useable and accessible ICT resources, effective

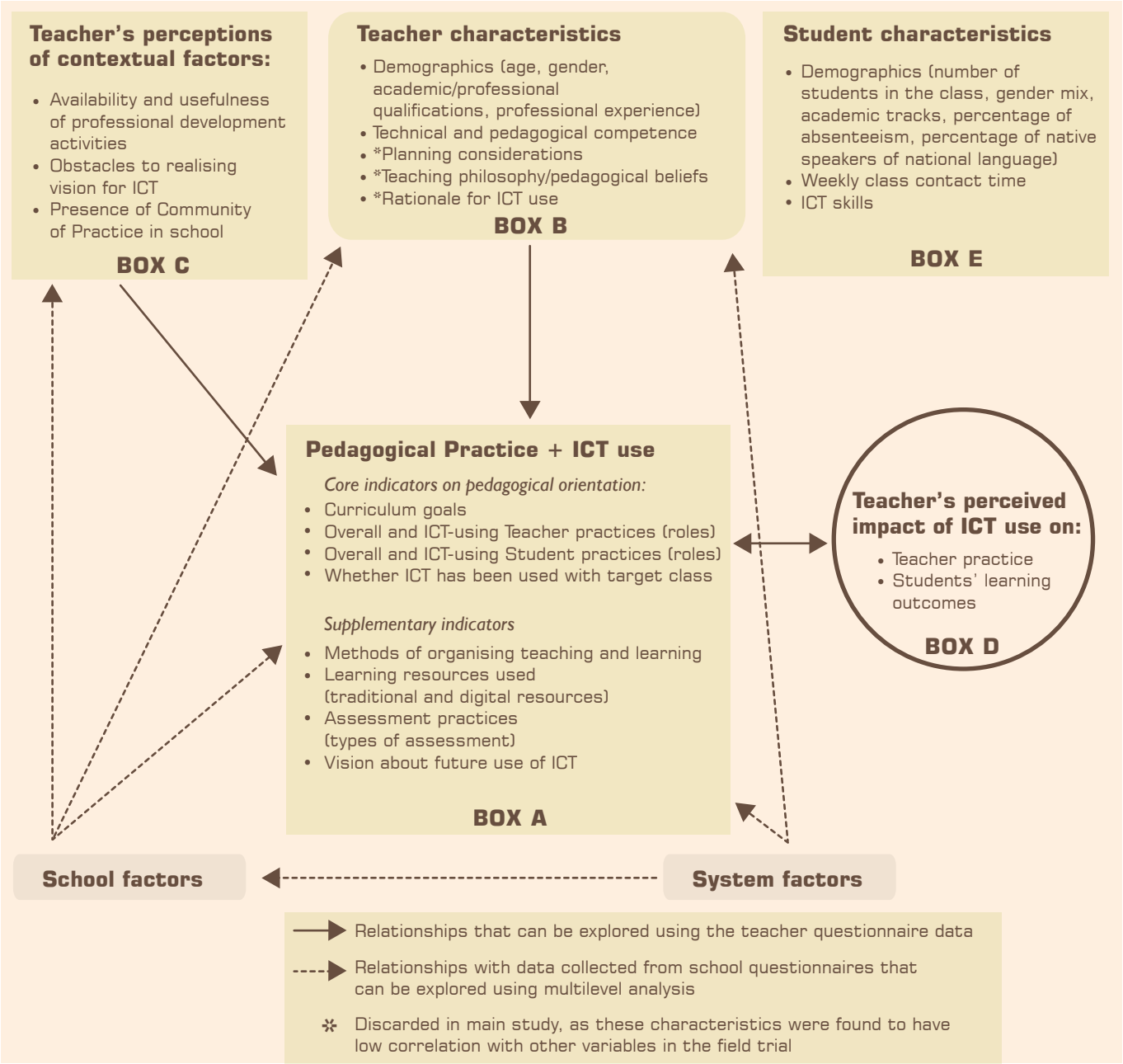
The implementation processes for teachers to successfully embed the use of digital curriculum resources into their teaching practice need to be aligned and integrated.

professional development, sufficient time, and technical support need to be provided to teachers. He further argues that 'no one component in itself is sufficient to provide good teaching. However, the presence of all components increases the possibility of [successful] integration of ICT in learning and teaching …' (Bingimlas 2009, page 235). These findings reflect research by Becta (2003, page 10) that successful integration of new technology depends on ICT resourcing, ICT leadership, ICT teaching, school leadership and general teaching quality, and is likely to vary across schools, curriculum areas and classrooms depending on the ways in which it is applied (Bingimlas 2009).

Law's (2009a) study of the pedagogical orientation of mathematics and science teachers and their use of ICT paralleled the findings from Becta (2003) and Bingimlas (2009) and found that a teacher's own personal characteristics, student characteristics and contextual factors at the school and system level are important influences on teaching practice and ICT use. Her study also includes a model (Law & Chow, in press) showing the relationships between these factors, as shown in Figure 5.

The focus on the need for alignment and integration of factors associated with teaching practice and use of digital technologies in the research by Law (2009a, 2009b) is also evident in the Exemplar Schools study conducted by Holkner et al (2008). Their research of exemplary ICT practice in six Australian schools supported the view that each school is a unique learning community and that educational research should not focus on trying to identify a 'one-size-fits-all' approach to using ICT in schools. Rather, they advocate an approach based on adopting 'appropriate practice' as determined by the particular needs of each school. They see school leaders as disseminators, planners, implementers and evaluators of innovative practice in their school communities and highlight their need for ongoing support in these roles.

Figure 5 Conceptual framework for research on factors influencing pedagogical practice and ICT use.



Source: Law & Chow, in press.

These findings are supported by Levin & Wadmany (2006) in their study of teachers' views about factors that enhance or inhibit the effective use of information technology. For example, they cite access, infrastructure, planning, teacher experience of technology and with innovation, staff development, expert and online technical and pedagogical support, knowledge of school needs, compatibility of the technology with school philosophy [ie culture], and leadership knowledge and support as indicative of the complexity in bringing about effective and sustained use of digital technologies.

Principles for embedding digital curriculum resources in teaching practice

These factors are also reflected in the review by Groff & Mouza (2008) of the challenges associated with effective technology integration. The areas of challenge were identified as: research and policy; the school (as the context); the teacher (innovator); the project (innovation); the students (operators); and the technology, as shown in Figure 6.

Based on this review, Groff & Mouza (2008) developed a framework, the Individualized Inventory for Integrating Instructional Innovations (The i5), to help teachers predict the likelihood of success of technology-based projects and identify potential barriers that can hinder their technology integration efforts.

The findings from the research literature demonstrate a high degree of commonality of factors which influence the implementation process. Equally consistent was the message from the literature that these factors act in concert, and are therefore best considered in combination. This brings the need for alignment and integration in implementation to the fore. An approach to tackling this challenge is proposed in the following section.

On the basis of the themes described in the research literature, the following sets of factors are proposed to guide the enhancement of teachers' take-up of digital content:

1. Contextual factors – to consider as background against which change is contemplated, for example policy, time, infrastructure, relevance, availability, suitability as these apply differentially to various stakeholders and to the nature of digital resources and supporting technology.

2. General change factors – to consider every time one thinks about change, for example leadership, culture, existing capabilities and skills, and reliability and useability of the technological tools.

3. Innovation-specific factors – to consider when one is thinking about specific innovations, as in this case: enhancing teachers' take-up of digital content.

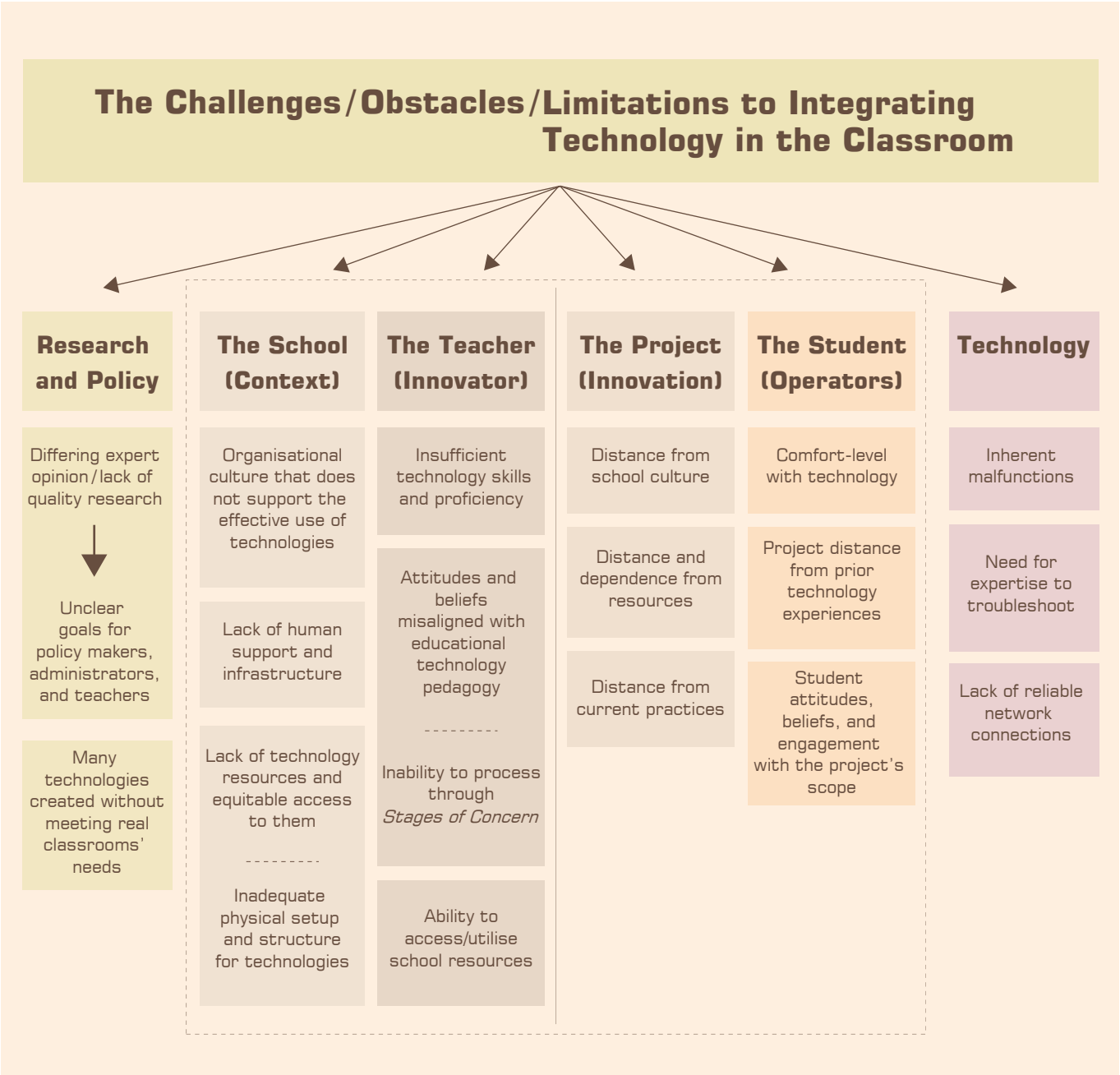
4. Systemic factors – to consider in looking at the whole picture (including the level of stakeholder awareness and consensus, as well as the degree of process alignment and integration evidenced in the contextual, general change, and innovation-specific factors).

These factor groupings have been drawn from the research literature on educational change (Fullan 1991; Fullan 2005; Hargreaves 2004; Harris 2000).

They highlight the multi-faceted and connected nature of factors influencing the implementation of change and the adoption of innovations. The relationships between the factors as they apply to various stakeholders (government, education authorities, schools, teachers and students) and the nature of digital curriculum resources (the content) and supporting technology (the tools) are represented in The Technology Adoption Model: Factors for enhancing teachers' take-up of digital content, shown in Figure 7 (see page 20).

The factors and relationships presented in the model give rise to a set of principles that schools and educational authorities can use in their efforts to enhance teachers' take-up of digital resources. The principles are grouped by the types of factors to which they most closely apply.

Figure 6 Challenges to classroom technology integration based on existing literature.



Source: Groff & Mouza 2008.

1. Contextual factors

1.1 Governments and education authorities have clear goals and policies for adoption.

1.2 The timeline for adoption by governments and education authorities (ie the political timeline) associated with policy development, program delivery and evaluation reflects the timeline for adoption by schools and teachers (ie the educational timeline) associated with finding, assessing relevance, take-up and refinement of the use of digital content.

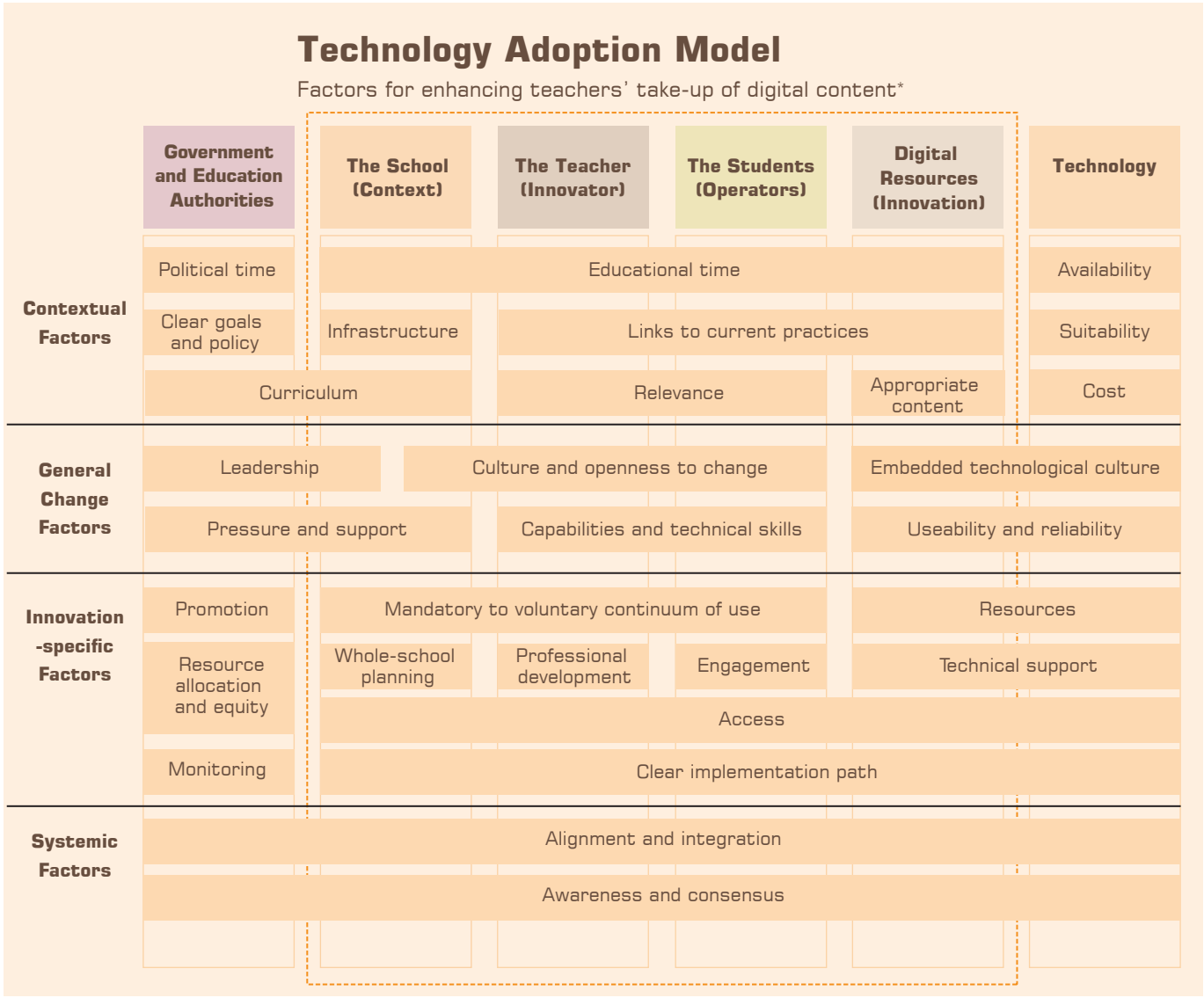
1.3 Schools have the infrastructure necessary for adoption, including available, suitable and affordable technological tools.

1.4 Teachers and students appreciate the relevance of the digital content and how it relates to the curriculum, and see links to current teaching and learning practices.

2. General change factors

2.1 Leaders in government, education authorities and schools encourage a culture of inquiry and openness to change.

Figure 7 Technology Adoption Model – Factors for enhancing teachers' take-up of digital content.



*This model was developed by Craig Ashhurst and Michael Gaffney.

2.2 Government and education authorities provide an appropriate balance of pressure and support for change.

2.3 The capabilities and technical skills of teachers and students are recognised as assets rather than liabilities.

2.4 The technological tools are reliable, useful and aligned with the school culture.

3. Innovation-specific factors

3.1 Digital content is readily accessible, links with the curriculum, and does what it purports to do.

3.2 There is a clear implementation path for adoption and it is linked to whole-school planning.

3.3 Government and education authorities allocate resources strategically and equitably, and have processes to promote and monitor the use of digital content.

3.4 Teachers and students have the resources to use digital content (including access to hardware and software, 'how to' guides, and expert technical and educational support).

4. Systemic factors

4.1 There is awareness and consensus among government, education authorities, school leaders, teachers and students about their philosophy of educational technology and the value of digital content, as well as the means by which the use of such content can benefit students.

4.2 The adoption process is designed and implemented so that the efforts of governments, education authorities, school leaders, teachers and students are aligned (through attention to the contextual, general change, innovation-specific, and systemic factors noted here) to achieve effective integration of digital content into teachers' pedagogical practice.

Conclusion

The review of the research and other scholarly writing undertaken for this report has revealed that enhancing teacher take-up of digital content is multi-faceted. It requires strategic and simultaneous attention to the:

- relevance of the digital curriculum resources
- appropriateness of the technological tools to deliver them
- capability of teachers to use them
- motivation and interest of students to learn with them
- culture of schools to institutionalise their use
- political will and capacity of governments and educational authorities to develop policy to promote and monitor their use
- importance of education systems developing awareness and shared understanding about the value of digital content
- means by which the actions of governments, education authorities, schools, teachers and students are aligned and integrated through the implementation process to increase teacher use of such resources for the benefit of students.

On the basis of these findings, a set of principles has been proposed to support teachers in embedding digital curriculum resources in their teaching practice. These principles have been grouped in terms of the contextual, general change, innovation-specific and systemic factors to which they most closely relate. It is hoped that these principles and the accompanying Technology Adoption Model – Factors for enhancing teacher take-up of digital content (see page 20) will prove useful to Australian schools and education authorities in informing policy to enhance teachers' use of digital curriculum resources for the benefit of all Australian students.

References

Allert, H., Dhraief, H. & Nedjl, W. (2002), Meta-Level Category 'Role' in Metadata Standards for Learning: Instructional Roles and Instructional Qualities of Learning Objects, COSIGN 2002, The 2nd International Conference on Computational Semiotics for Games and New Media.

Ashhurst, C. & Gaffney, M. (forthcoming), *Take Up and Take Off: Strategies for Enhancing the Wise Use of Digital Technologies.*

Balanskat, A., Blamire, R. & Kefala, S. (11 December 2006), The ICT Impact Report: A Review of ICT Impact on Schools in Europe, Retrieved 16 July 2008, from http://ec.europa.eu/education/pdf/doc254_en.pdf.

Barber, M. & Mourshed, M. (2007), *How the World's Best-performing School Systems Come out on Top*, London: McKinsey.

Betcher, C. & Lee, M. (2009), *The Interactive Whiteboard Revolution: A Teacher's Guide to IWBs*, Melbourne: ACER Press.

The Big Bus UK – educational software company, www.thebigbus.com.

Bingimlas, K. A. (2009), 'Barriers to the successful integration of ICT in teaching and learning environments: a review of the literature', *Eurasia Journal of Mathematics, Science & Technology Education*, 5 (3), 235–245.

Bore, A. & Wright, N. (2009), 'The wicked and complex in education: developing a transdisciplinary perspective for policy formulation, implementation and professional practice', *Journal of Education for Teaching: International Research and Pedagogy*, 35 (3), 241–256.

Borko, H., Whitcomb, J. & Liston, D. (2009), 'Wicked problems and other thoughts on issues of technology and teacher learning', *Journal of Teacher Education*, 60 (1), 3–7, doi: 10.1177/0022487108328488.

British Educational Communications and Technology Agency, www.becta.org.uk.

British Educational Communications and Technology Agency (2004), A Review of the Research Literature on Barriers to the Uptake of ICT by Teachers, Becta Research.

British Educational Communications and Technology Agency (2005), The Becta Review 2005: Evidence on the progress of ICT in education. British Educational Communications and Technology Agency. Retrieved January 2, 2008, from http://foi.becta.org.uk/content_files/corporate/resources/policy_and_strategy/board/0503-mar/becta_review_2005.pdf.

British Educational Communications and Technology Agency (2006), The Becta Review 2006. Retrieved July 16, 2008, from http://publications.becta.org.uk/display.cfm?resID=25948.

British Educational Communications and Technology Agency (2007), Harnessing Technology Review 2007: Progress and Impact of Technology in Education: Summary Report. Retrieved July 16, 2008, from http://publications.becta.org.uk/display.cfm?resID=33980.

British Educational Communications and Technology Agency (2008), Harnessing Technology review 2008: The Role of Technology and Its Impact on Education, Becta, Viewed 19 September 2009, from http://publications.becta.org.uk/display.cfm?resID=38751.

British Educational Communications and Technology Agency (2009), Harnessing Technology for Next Generation Learning: Children, Schools and Families Implementation Plan 2009–2012, Becta, viewed 19 September 2009, from http://publications.becta.org.uk/display.cfm?resID=39547.

Buchan, J. (2008), Tools for Survival in a Changing Educational Technology Environment, Paper presented at the Hello! Where are you in the landscape of educational technology? Proceedings ascilite Melbourne 2008, Melbourne, Australia. www.ascilite.org.au/conferences/melbourne08/procs/buchan.pdf.

Buchan, J., Flynn, L., Murdoch, D. & Uys, P. (2008), A decade of change @ CSU 1999–2009. Paper presented at the Hello! Where are you in the landscape of educational technology? Proceedings ascilite, Melbourne 2008. www.ascilite.org.au/conferences/melbourne08/procs/buchan-poster-2.pdf.

Cambridge University Press, www.cambridge.org.

ClickView – the digital video solution for schools, www.clickview.com.au.

Condie, R. & Munro, B. with Seagraves, L. & Kenesson, S. (2007), The Impact of ICT on Schools: A Landscape Review, Becta Research.

Cox, M., Webb, M., Abbott, C., Blakeley, B., Beauchamp, T. & Rhodes, V. (2004), ICT and Attainment: A Review of the Research Literature, ICT in Schools Research and Evaluation Series, no 17. BECTA/DfES, London. Retrieved 4 February, 2006, from http://partners.becta.org.uk/upload-dir/downloads/page_documents/research/ict_attainment_summary.pdf.

Cuban, L. (1986), *Teachers and Machines: The Classroom Use of Technology Since 1920*, New York: Teachers College Press.

Cuban, L. (2001), *Oversold and Underused Computers in the Classroom*, London: Harvard University Press.

Department for Children, Schools and Families (UK), www.dcsf.gov.uk.

Dikbas Torun, E., Kocak Usluel, Y. & Ilgaz, H. (2008), Teachers' Adoption of Laptops in the Stages of Innovation Decision Process, Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications, 2008.

Duignan, P. (2006), *Educational Leadership: Key Challenges and Ethical Tensions*, Cambridge: Cambridge University Press.

Ellul, J. (1964), *The Technological Society*, New York: Vintage Books.

Ellul, J. (1968), 'Technique, institutions and awareness', *The American Behavioral Scientist*, (pre-1986), 11(6), 38, Retrieved April 14, 2010, from ABI/INFORM Global. (Document ID: 725016981).

Finger, G. & Jamieson-Proctor, R. (2010), 'Teacher Readiness: TPACK capabilities and redesigning working conditions', in Lee, M. & Finger, G. (Eds), *Developing a Networked School Community: A Guide to Realising the Vision*, Melbourne: ACER Press.

Franklin, C. (2007), 'Factors that influence elementary teachers' use of computers', *Journal of Technology and Teacher Education*, 15 (2), 267–293.

Freebody, P. (2005), 'Does the use of online curriculum content enhance motivation, engagement and learning?' The Le@rning Federation trial review, report to Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), Retrieved 1 February, 2006, from http://www.thelearningfederation.edu.au/verve/_resources/freebody2005_report__final.pdf.

Freeman, V. (2008), Determining the Cost/Benefit of Le@rning Objects, Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications, 2008.

Freisen, N. (2004), 'Three objections to Learning Objects and e-learning standards', Draft version of a paper published in McGreal, R. (Ed.) Online Education Using Learning Objects, London: Routledge, pages 59–70.

Friedman, T. (2006), *The World is Flat* (2nd Ed.), New York: Farrar, Straus & Giroux.

Fullan, M. (2001), T*he New Meaning of Educational Change*, New York: Teachers College Press.

Fullan, M. (2005), *Leadership & Sustainability: System Thinkers in Action*, Thousand Oaks: Corwin Press.

Gartner Consulting (2006), Emerging Technologies Hype Cycle 2006, www.gartner.com/it/page.jsp?id=1124212.

GeoGebra – free and multi-platform dynamic mathematics software, www.geogebra.org/cms.

Groff, J. & Mouza, C. (2008), 'A framework for addressing challenges to classroom technology use', *AACE Journal*, 16 (1), 21–46.

Hargreaves, A. (2004), 'Inclusive and exclusive educational change: emotional responses of teachers and implications for leadership', *School Leadership & Management*, 24 (2).

Harris, A. (2000), 'What works in school improvement? Lessons from the field and future directions', *Educational Research*, 42 (1), 1–11.

Holkner, B., Romeo, G., Henderson, M., Auld, G., Russell, G., Wee T. S. & Fernando, A. (2008), *Exemplar Schools: Using Innovative Learning Technologies*, Monash University.

ISTE (2007), National educational technology standards for students: the next generation, **www.iste.org**.

Keane, T. (2008), 'Lead on: ICT leadership in schools', *Teacher.*

Kopcha, T. J. (2010), 'A systems-based approach to technology integration using mentoring and communities of practice', *Educational Technology Research & Development*, 58 (2), 175-190. doi: 10.1007/s11423-008-9095-4.

Law, N. (2009a), 'Mathematics and science teachers' pedagogical orientations and their use of ICT in teaching', *Education and Information Technologies*, 14, 309–323.

Law, N. (2009b), Technology-supported pedagogical innovations: the challenge of sustainability and transferability in the information age, in C. C. Ng & P. D. Renshaw (Eds.), *Reforming Learning*, Springer Science Business Media.

Law, N. & A. Chow (in press), 'Developing the teacher questionnaire' in R. Carstens & W. J. Pelgrum (Eds.), IEA SITES 2006 Technical Report. Amsterdam: International Association for the Evaluation of Educational Achievement.

The Le@rning Federation, **www.thelearningfederation.edu.au**.

Lee, J., Cerreto F. A. & Lee, J. (2010), 'Theory of planned behavior and teachers' decisions regarding use of educational technology', *Educational Technology and Society*, 13 (1).

Lee, M. & Finger, G. (Eds) (2010), *Developing a Networked School Community: A Guide to Realising the Vision*, Melbourne: ACER Press.

Lee, M. & Gaffney, M. (Eds) (2008), *Leading a Digital School*, Melbourne: ACER Press.

Lee, M. & Winzenried, A. (2009a), *The Use of Instructional Technology in Schools*, Melbourne: ACER Press.

Lee M. & Winzenried, A. (2009b), 'Interactive whiteboards: achieving total teacher usage', *Australian Educational Leader*, 28 (3), 22–25.

Levin, T. & Wadmany, R. (2006), Learning from Experience: Teachers' Views on Factors Enhancing or Inhibiting Effective Use of Information Technology in the Rich-technology Classroom, Paper presented at the Society for Information Technology & Teacher Education International Conference 2006, Orlando, Florida.

Lim, W. Y., Lee, Y. J. & Hung, D. (2008), 'A prophet never accepted by their own town: a teacher's learning trajectory when using technology', *Asia-Pacific Journal of Teacher Education*, 36 (3), 215–227.

Lovekin, D. (1977), 'Jacques Ellul and the logic of technology', *Man and World*, 10 (3), 251–272, [10.1007/BF01248590].

Mishra, P. & Koehler, M. J. (2006), 'Technological Pedagogical Content Knowledge: a framework for teacher knowledge', *Teachers College Record*, 108 (6), 1017–1054, **http://punya.educ.msu.edu/publications/journal_articles/mishra-koehler-tcr2006.pdf**.

Moyle, K. (2010), 'Building innovation: learning with technologies', *Australian Education Review*, 56 (1).

Mulkeen, A. (2003), 'What can policy makers do to encourage integration of information and communications technology? Evidence from the Irish school system', *Technology, Pedagogy and Education*, 12 (2), 277–293.

Mumtaz, S. (2000), 'Factors affecting teachers' use of information and communications technology: a review of the literature', *Journal of Information Technology for Teacher Education*, 9 (3), 319–342.

Orlando, J. (2009), 'Understanding changes in teachers' ICT practices: a longitudinal perspective', *Technology, Pedagogy and Education*, 18 (1), 33–44.

Prensky, M. (2001), 'Digital natives, digital immigrants', *On the Horizon*, 9 (5), NCB University Press.

Promethean Planet – free online community for ActivClassroom teachers, **www.prometheanplanet.com**.

Rogers, E. M. (1962), *Diffusion of Innovations*, New York: The Free Press.

Rosman L., White, G. & Kerry-Anne Hoad (2008), *A Digital Education Revolution: Realising the Possibilities, Managing the Realities*, ACER, **http://works.bepress.com/gerry_white/2**.

Rowe, L. (2008), 'Ways in which teachers plan for, implement, and review the use of learning objects as part of a primary school mathematics program', Masters in Information Technology in Education thesis, University of Melbourne.

Runyon, L. & Semich, G. (2002), Infusing Technology in the Classroom: Positive Intervention Makes the Real Difference in Student Learning. Paper presented at the Society for Information Technology & Teacher Education International Conference 2002, Nashville, Tennessee.

Scootle – **www.scootle.edu.au**.

Selwyn, N. (2007), 'Curriculum online? Exploring the political and commercial construction of the UK digital learning marketplace', *British Journal of Sociology of Education*, 28 (2), 223–240.

Shulman, L. (2006), 'Those who understand: knowledge and growth in teaching', *Educational Researcher*, 15 (2), 4–14.

Shulman, L. (2007), 'Knowledge and teaching: foundations of the new reform,' *Harvard Educational Review*, 57 (1), 1–22.

Strijker, A. & Collis, B. (2006), 'Strategies for reuse of learning objects: context dimensions', *International Journal on E-Learning*, 5 (1), 89–94.

Toffler, A. (1970), *Future Shock*, New York: Random House.

Tyack, D. & Cuban, L. (1995), *Tinkering with Utopia: A Century of Public School Reform*, Cambridge: Harvard University Press.

Vallance, M. (2008), 'Beyond policy: Strategic actions to support ICT integration in Japanese schools', *Australasian Journal of Educational Technology*, 24 (3), 275–293.

Venezky, R. & Davis, C. (2002), *Quo Vademus? The Transformation of Schooling in a Networked World*, OECD/CERI.

Victory, M., Wiles, A & Topp, C. (2008), 'The innovation is not the technology', *Teacher Learning Network*, 15 (3), 23–25.

Ward, L. (2008), Teacher practice and the integration of ICT: Why aren't our secondary school teachers using computers in their classrooms? **www.google.com.au/search?client=safari&rls=en&q=Lorrae+Ward&ie=UTF-8&oe=UTF-8&redir_esc=&ei=Xsa6S-T_D4Ge6gPi8rXbBQ**

Zhao, Y. (2007), 'Social studies teachers' perspectives of technology integration', *Journal of Technology and Teacher Education*, 15(3), 311–333.

Zhao, Y. & Cziko, G. (2001), 'Teacher adoption of technology: a perpetual control theory perspective', *Journal of Technology and Teacher Education*, 9 (1), 5–30.


9 781742 001098