

Transforming learning with information and communication technologies: Insights from three decades of research



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Romina's teaching and research interests and endeavours focus on the use of information and communication technologies (ICT) to enhance and transform teaching and learning to meet the needs of 21st-century learners. Romina's work in this field is recognised nationally and internationally: she has won several awards at Australian Council for Computers in Education conferences; received more than \$1.9m in external competitive grants and consultancies; and been endowed with a Schooling 2001 Queensland Award for contribution to the integration of learning technology in Queensland schools as well as a QUT Postdoctoral Fellowship to further her doctoral findings related to the impact of ICT on higher order thinking, problem solving and creativity. Romina has extensive experience in the leadership and management of large scale pure and applied research projects, specifically investigating the impact of ICT on teaching and learning across state and national education systems and was integral in the adoption of the Technological Pedagogical Content Knowledge (TPACK) framework in the National Teaching Teachers for the Future project and the creation of the survey instrument used to measure pre-service teachers' TPACK confidence and capability (2011–2012). Romina has expertise in quantitative methods, especially the design and development of theoretically and statistically valid and reliable measurement instruments to gauge student attitude to computers, student creative dispositions, teacher confidence and capability to integrate ICT, and teacher TPACK.

Abstract

Since computers first appeared in classrooms, educators have sought to integrate information communication technologies (ICT) into teaching and learning. In Australia, as elsewhere, ICT are widely regarded as critical facilitators of student learning. The ability to use ICT effectively is specified in Australia's national curriculum as a required general capability. However, despite the educational environment being replete with ICT related programs, our understanding of how students use ICT for learning is still limited. This paper presents insights from the past 30 years of research, which suggest that even though the current 'climate' in Australian schools is favourable, teacher confidence and capability to transform their pedagogy with ICT requires robust, evidence-based frameworks and tools that will support teachers to critically analyse the affordances of ICT, and plan transformative learning experiences for their students. A framework to guide teacher development and practice, the Technological Pedagogical and Content Knowledge (TPACK) model is described, as well as the Teaching Teachers for the Future (TTF) TPACK Survey, which assesses teacher beliefs about how their students use ICT to achieve learning outcomes. Attention is then focused on the potential for creative thinking that is enabled when ICT is integrated as a 'mindtool' for learning. The paper concludes by proposing an explanatory framework that describes a systems perspective for student creativity in classrooms, Distributed Creativity (DC), which accounts for variables that impact student creativity and provides teachers with a scaffold from which to plan and assess student use of digital technologies for learning and creative thinking.

Introduction

Since the introduction of computers into Australian classrooms in the early 1980s, educators have sought to integrate information communication technologies (ICT) into teaching and learning, while researchers have examined the affordances and impact of these technologies, which are widely regarded as critical facilitators of student learning. A review of research suggests that the transformation of education as a result of the integration of ICT can be envisaged as occurring across three 'waves' (e.g., Finger, Russell, Jamieson-Proctor, & Russell, 2007). In the first wave (circa 1980–1990), computers were introduced as a new educational tool in a similar manner to previous technologies such as the overhead projector, and were principally viewed as an object of study. In the second wave (circa 1990–2000), the value of ICT as an educational resource began to be recognised and teachers, beyond those responsible for computing subjects, saw the potential for ICT to be integrated across a range of learning areas. In the third wave (post 2000), the value of ICT is being recognised as a means to fulfil emerging needs and accomplish new goals (Norton & Wiburg, 2003).

Recent research confirms that students and their teachers are increasingly becoming third-wave users of ICT (Jamieson-Proctor, Redmond, Zagami, Albion, & Twining, 2014). With the increasing availability of digital devices within schools and the community, students are able to choose how, when, where and with whom they engage in learning. At the same time teachers are able (indeed encouraged) to redefine their pedagogy. Nonetheless, the literature indicates that some educators ignore the information-rich world shaping

students' non-school experiences (Yelland, 2007). As a result, many students find learning in school irrelevant to their real (digital) lives.

The challenge for educators and systems is to learn about and capitalise on the affordances of 21st-century technologies for teaching and learning so that students are being 'primed' for the demands of living and working in a rapidly changing information environment (Chubb, 2015). In this paper, I argue that it is not only time for all educators to embrace the third-wave potential of digital technologies, it is also time to engage with the affordances of a fourth-wave approach; utilising digital technologies as 'mindtools' that can transform curriculum and pedagogy and enable students to be and become more innovative and creative (Beghetto & Kaufman, 2007).

Policy trends for using information and communication technologies in the curriculum

In response to the challenge posed by rapid and increasing world-wide digitisation, education systems nationally and internationally have reviewed their curriculum. In Australia, *The Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA, 2008a) led to the development of Australia's first national curriculum, the *Foundation to Year 12 Australian Curriculum* (ACARA, 2016), which sets the expectation that all young Australians, regardless of their circumstances, should become highly skilled in using ICT.

ICT is specified as a general capability in the national curriculum and students are required to communicate, investigate and create with ICT; apply social and ethical

protocols and practices with ICT; as well as manage and operate ICT across all learning areas (ACARA, n.d.). Such expectations go far beyond simply using ICT to access content, to requiring that students attain 21st century learning outcomes: communication, collaboration, critical thinking and creativity (Partnership for 21st-Century Learning, 2007). Given the pervasive presence of ICT in the Australian Curriculum, the integration of ICT should have transformed objectives and content, learning outcomes, and pedagogy. But has it?

Governments and some educators recognise that new forms of teaching and learning are needed but 'many school systems continue to value and promote old learning and the associated outcomes related to the possession of specific and privileged knowledge' (Yelland, 2007, pp. 121–122). For teachers who trained before the development of digital technologies, preparing themselves and others to utilise rapidly developing digital technologies effectively is a challenge (Luke, 2001). Accordingly, many teachers tend to focus on integrating new technologies rather than transforming established curriculum and pedagogical approaches in order to realise the potential of ICT to facilitate creative and innovative thinking

Good practice and leadership in the use of ICT in schools (DETYA, 2000) emphasised the complexity that educators find themselves in by identifying four different but overlapping dimensions of ICT use in classrooms:

- a tool for use across the curriculum where the emphasis is on the development of ICT-related skills, knowledge, processes and attitudes
- a tool for enhancing students' learning outcomes within the existing curriculum and using existing learning processes
- an integral component of broader curriculum reforms, which will change not only how students learn but what they learn
- an integral component of the reforms, which will alter the organisation and structure of schooling itself.

The last two dimensions of ICT use clearly transcend earlier conceptualisations and portray ICT as part of a broader movement toward curriculum and school reform (Fluck, 2003; Nichol & Watson, 2003).

In order for Australian schools to meet the demands of the 21st century, the federal government funded the Digital Education Revolution (DER, 2008). The DER, which was guided by the *Joint ministerial statement on information communication technologies in Australian education and training; 2008–2011* (MCEETYA, 2008b), provided a national framework for cross-sector sharing of resources and expertise. When DER funding ended, Australian school communities had come to expect

1:1 computing. Thus, state and territory governments had to consider options such as *bring your own* (BYO) technology (Bita & Chilcott, 2013).

Given ICT enablement of technology-rich learning environments in Australian schools (and society more generally), as well as the pedagogical transformations described in the MCEETYA, demanded by the Australian Curriculum, and reinforced by Australian education policy statements, are fourth- or even third-wave approaches to integrating ICT in teaching and learning evident?

Teacher confidence in utilising information and communication technologies in the curriculum

In order to answer this question, researchers have examined teacher confidence to utilise ICT across the curriculum. The results of two large-scale studies to evaluate teacher confidence to use ICT in teaching and learning indicated that teacher gender and teacher confidence had a direct positive relationship with the quantity and quality of student use of ICT (Jamieson-Proctor, Burnett, Finger, & Watson, 2006; Jamieson-Proctor & Finger, 2008a, 2008b). Specifically, male, and more confident teachers were using ICT to enhance and transform the curriculum to a greater extent than female, and less confident teachers. Given that more than 70 per cent of Australian teachers are female, it could be inferred that many students are not experiencing equitable access to teaching and learning in which ICT use is integral to learning. In turn, this suggests that a one-size-fits-all model of teacher professional development for integrating ICT effectively in teaching and learning has not been effective. In order for desired student outcomes to be achieved, ongoing research examining barriers to teacher confidence to integrate ICT is needed (Jamieson-Proctor et al., 2006; Prestridge, 2008), as is evidence-based, pedagogically focused professional development to build teacher capacity to transform teaching and learning through technology (Ertmer & Ottenbreit-Leftwich, 2010; Jamieson-Proctor et al., 2014; Prestridge, 2014). Only then will greater evidence of third- and fourth-wave approaches be seen in Australian classrooms.

The Teaching Teachers for the Future project and initial teacher education in Australia: A framework guiding teacher development and practice

The necessity for teachers to develop pedagogically focused ICT capabilities is also recognised in the Australian Professional Standards for Teachers (AITSL, 2017), which prescribe rigorous expectations for initial teacher education (ITE) programs as well as for practising teachers. The Teaching Teachers for the

Future (TTF) project was an initiative funded by the ICT Innovation Fund (ICTIF) to guide early career teachers to better utilise ICT in teaching and learning. This project, which involved all 39 Australian higher education ITE providers, as well as state and federal governments and education agencies, aimed to enhance pre-service teachers' Technological Pedagogical Content Knowledge (TPACK); based on the conceptual framework developed by Mishra and Koehler (2006). As shown in Figure 1, TPACK provides teachers and teacher-educators with a valuable explanatory model that accounts for teachers' technological knowledge (TK), content knowledge (CK), and pedagogical knowledge (PK) and the intersections of these knowledge domains.

In addition, to the provision of a strong explanatory framework to guide teacher development and practice, the TTF project also resulted in the development of a robust measure, the TTF TPACK Survey (Jamieson-Proctor et al., 2013), designed to examine pre-service teachers' TPACK. The development of this measure was built upon the foundation of three earlier instruments: the ICT Curriculum Integration Performance Measurement Instrument (Jamieson-Proctor, Watson, & Finger, 2004); the Learning with ICTs: Measuring ICT Use in the Curriculum instrument (Jamieson-Proctor et al., 2004; Jamieson-Proctor, Watson, Finger, Grimbeek, & Burnett, 2007) and the TPACK Confidence Survey (TCS) (Albion, Jamieson-Proctor, & Finger, 2010).

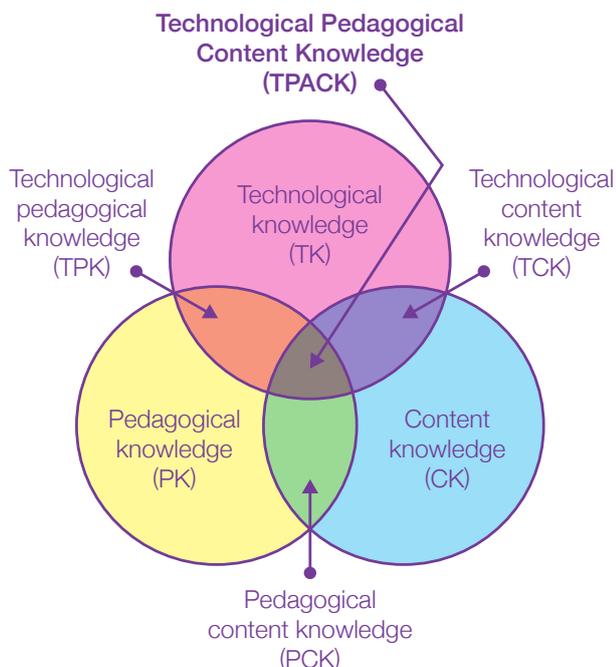


Figure 1 Technological Pedagogical Content Knowledge (TPACK)

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Tools for assessing the impact of information and communication technologies on student learning

The developmental trajectory of the three measures informing the construction of the TTF TPACK Survey (Jamieson-Proctor et al., 2013) is noteworthy for several reasons. First, the researchers developed and applied a consistent definition of ICT integration, thus addressing a shortcoming observed in the literature (Jamieson-Proctor & Finger, 2008b). Second, the studies were large scale, involving thousands of teachers across schools and systems; for example, the study conducted by Jamieson-Proctor et al. (2007) involved 10 433 and 4473 pre-service teachers, pre- and post-intervention respectively. In contrast, previous studies were generally small-scale case studies of 'lighthouse' projects (Jamieson-Proctor & Finger, 2008b). Third, the researchers moved beyond accounting for input measures (e.g. numbers of computers, funding for teacher professional development) to determining output measures such as the quantity and quality of student experiences of integrated ICT and the resultant impact on their learning outcomes (Jamieson-Proctor, Watson, & Finger, 2004).

The TTF TPACK Survey, which emerged from an extensive review of the literature on ICT curriculum integration (e.g., Fitzallan, 2004; Jamieson-Proctor, Watson, & Finger, 2004; Trinidad, Clarkson, & Newhouse, 2005), as well as the development of the three earlier measures (Albion et al., 2010; Jamieson-Proctor et al., 2004; Jamieson-Proctor et al., 2007), was administered pre and post the year long TTF intervention. Findings demonstrated measurable growth in pre-service teachers' self-perceptions of their confidence to use ICT, within a range of pedagogical strategies, to support their future students' learning (Finger et al., 2013; Jamieson-Proctor et al., 2013).

In summary, teachers and teacher-educators at this time can confidently rely on this valuable explanatory model (TPACK) to guide them in integrating ICT in teaching and learning. In addition, a robust measure (TPACK Survey) is available to assess teachers' TPACK across core learning areas (Jamieson-Proctor et al., 2013). While the model and survey tool are sufficient to support educators in third-wave integration of ICT to facilitate teaching and learning, they are insufficient for teachers seeking to take advantage of the potential power of ICT digital technologies to become cognitive tools or 'mindtools' that facilitate student creative thinking. In order to support teachers in engaging with fourth-wave approaches to teaching and learning with ICT, an expanded explanatory model such as the 'Distributed Creativity: A systems perspective for student creativity in classrooms' (Figure 2, p. 24) is proposed.

Utilising information and communication technologies to enhance students' creativity: The fourth wave?

In parallel with my work examining the integration of ICT, I have also investigated the development of creativity, higher-order thinking and problem solving as a result of this integration (Jamieson-Proctor, 1999; Jamieson-Proctor & Burnett, 2004). Since my earliest experiences with computers in classrooms, I have been fascinated by the power of these digital mindtools to transform the curriculum, and teaching and learning, affording students the classroom contexts, content and dispositions to be and become creative (Beghetto & Kaufman, 2007). Further, evidence from the large-scale studies, many cited in this paper, has convinced me that students' creative thinking can be enhanced when they work collaboratively with access to appropriate digital technologies as 'mindtools' (Jamieson-Proctor & Larkin, 2012; Jamieson-Proctor, 1999; Jamieson-Proctor & Burnett, 2002). As a consequence, I have developed a systems perspective on student creativity in classrooms (Jamieson-Proctor & Albion, 2016).

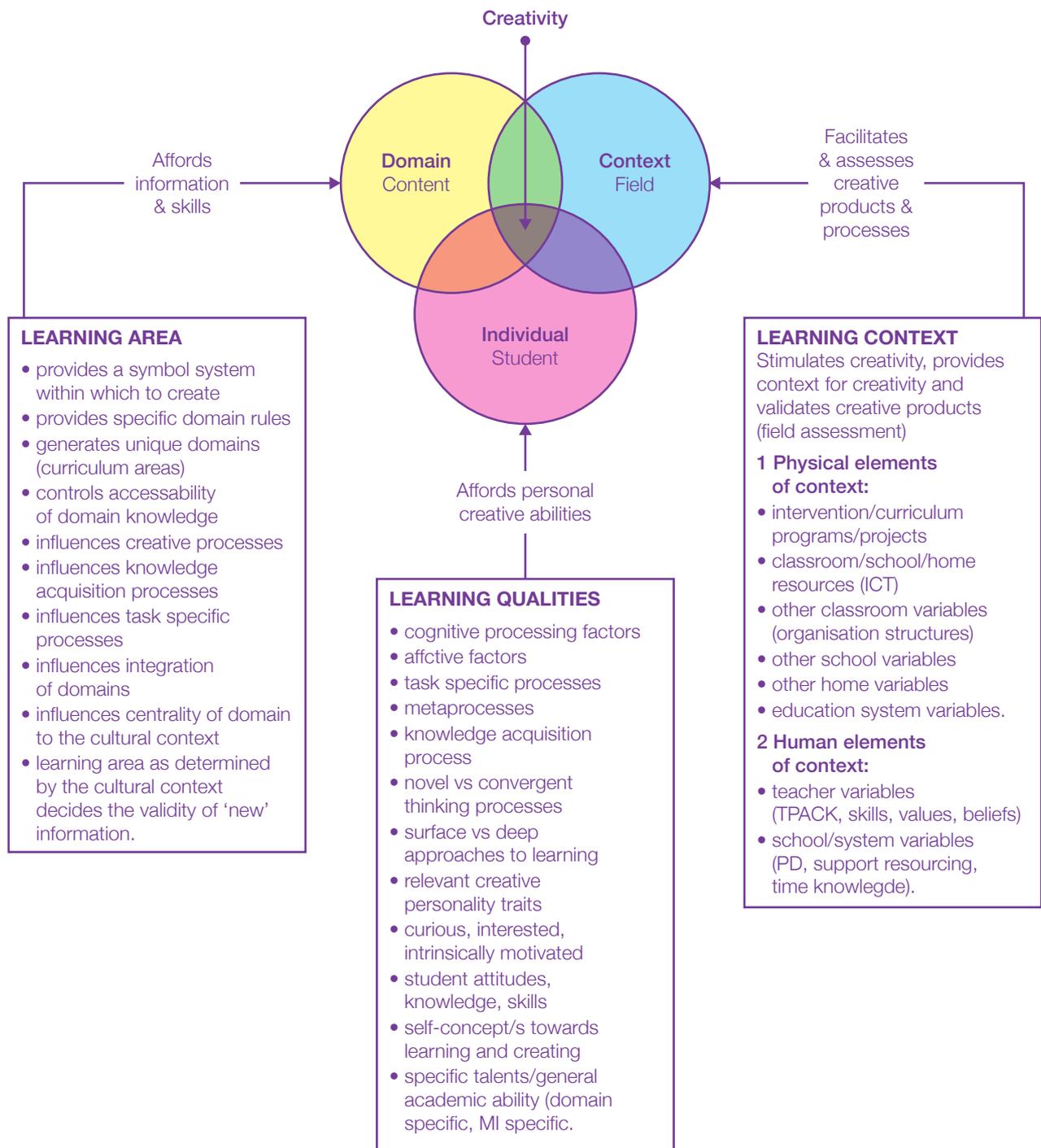
The uses of ICT to support and promote creativity have been described, reviewed and theorised in a number of research studies and a conceptual framework for creativity and ICT in primary classrooms has been proposed (Loveless, Burton, & Turvey, 2006). Nonetheless, educators' understanding and practical implementation of enhancing creativity with ICT need further explication. Thus, a theoretical framework for creativity in 21st century technology-rich classrooms (Figure 2) is proposed, which accounts for current theories and previous research with respect to creativity, particularly 'mini-c' creativity (Beghetto & Kaufman, 2007), as well as for essential interactions among individuals, domains and contexts. The framework can support critical analysis of the ways in which ICT supports creativity and assists teachers to organise learning with and through ICT by encouraging learners to collaborate, create meaning, make curriculum connections, and develop personal creative abilities and dispositions.

Distributive Creativity: A systems perspective for student creativity in classrooms

The Distributive Creativity (DC) framework (Figure 2) assumes that creativity arises from the interactions among person, domain and sociocultural context. This implies a study of creativity as a system, asking not what is creativity, but more importantly, where is creativity? The DC framework identifies the dependent variables that are predicted to impact student creativity across learning areas (domain), learning contexts (context) and learning qualities (individual). These

variables, derived from creativity research, are specific to learning contexts where students can operate in and manipulate the symbol system of a particular domain within a learning context that can be observed or described. The model recognises that students bring their individual learner qualities to bear on each learning task in order to create an innovative response that is validated by others (teachers, peers, parents/caregivers) who are also part of the learning context.

While educators could use the framework for instructional planning (e.g., designing learning activities in which students are required to use their devices and connectivity to create novel products in a specific learning area, or across learning areas both within and beyond the physical classroom); researchers could use the framework to develop observation tools and measurement instruments within and across the three elements of learning area, learning context and learning qualities.



LEARNING AREA

- provides a symbol system within which to create
- provides specific domain rules
- generates unique domains (curriculum areas)
- controls accessibility of domain knowledge
- influences creative processes
- influences knowledge acquisition processes
- influences task specific processes
- influences integration of domains
- influences centrality of domain to the cultural context
- learning area as determined by the cultural context decides the validity of 'new' information.

LEARNING QUALITIES

- cognitive processing factors
- affective factors
- task specific processes
- metaprocesses
- knowledge acquisition process
- novel vs convergent thinking processes
- surface vs deep approaches to learning
- relevant creative personality traits
- curious, interested, intrinsically motivated
- student attitudes, knowledge, skills
- self-concept/s towards learning and creating
- specific talents/general academic ability (domain specific, MI specific).

LEARNING CONTEXT

Stimulates creativity, provides context for creativity and validates creative products (field assessment)

1 Physical elements of context:

- intervention/curriculum programs/projects
- classroom/school/home resources (ICT)
- other classroom variables (organisation structures)
- other school variables
- other home variables
- education system variables.

2 Human elements of context:

- teacher variables (TPACK, skills, values, beliefs)
- school/system variables (PD, support resourcing, time knowlegde).

Figure 2 Distributed Creativity: A systems perspective for student creativity in classrooms

Conclusion

So, what have I learnt from three decades of research into ICT use in classrooms? First, educational change is difficult and complex. Although ICT has brought new possibilities and urgencies (Norton & Wilburg, 2003), 'digital expectancy' and national initiatives such as the DER and TTF have not been enough to transform teaching and learning. Second, we need to ask the right questions. While many studies have examined the

impact of the computer as a tutor or tool, very few have explored the potential of digital technologies to become 'mindtools' that allow individuals to engage in multiple forms of thinking (Jonassen, 2000). Third, we have learnt that there are significant challenges for educators seeking to frame and develop creativity in schools. Despite 'critical and creative thinking' being specified as a general capability in the national curriculum,

there is little agreement on how creativity should be envisioned, defined and enacted in schools (Jamieson-Proctor & Burnett, 2002). Fourth, teachers have not had a dependable workable framework to guide them in providing students with opportunities to develop the 4Cs (communication, collaboration, creativity and critical thinking) and their potential for creative thinking (Mishra, Koehler, & Henriksen, 2011). Finally, teachers face challenges in negotiating a path between standards and accountability and creative learning, where there is a commitment to nurturing ingenuity, flexibility and generative capability (Craft, 2005; DEST, 2002).

Although the power of ICT to transform education has yet to be fully realised, insights from the last 30 years of research suggest that the current 'climate' in Australian schools is favourable for curriculum and pedagogical transformation. We know that teacher confidence and capability (2Cs) to transform their pedagogy with ICT is dependent on their knowledge base (TPACK), as well as upon the development of robust theoretical frameworks and tools with which to critically analyse the affordances of ICT and promote transformative learning experiences for students (4Cs). The proposed DC framework delineates potential links between curriculum and classroom that can assist educators to better understand and enhance the creative thinking of students with the range of digital technologies at their disposal. Thus, in seeking to answer the *big* question, 'What if education departments, schools and individual teachers had the confidence, capabilities and resources to optimise student creative potential and transform the curriculum, teaching and learning with ICT?'. Findings indicate that teacher preparation and ongoing professional learning opportunities are critical, as is understanding the role ICT can play in transforming the curriculum and pedagogy to engage students in the 4Cs.

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