Critical Review and Analysis of the Issue of "Skills, Technology and Learning"

Final Report

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Section 1: Executive Summary

1.1. Introduction

"Twenty-first century skills, technology and learning" is a term used to signal educational change in policies and practices, and has been widely and loosely defined in terms of the needs of the 'next generation' of learners. This report examines current educational research, policies, and where possible, on the ground practices of teachers and learners within this broad framework.

Drawing on published research, policy reports, and grey literature associated with 21st century skills, technology and learning[1], we provide a critical analysis of the issues facing educational reform in the 21st century, addressing in particular the following two questions:

1) What are the major themes and trends in relation to 21st century skills, technology and learning?
2) What, if any, are the impacts of skills, technology and learning on student achievement and instructional practices?

Before addressing these questions in detail, we begin with a discussion of the ways in which 21st century skills, technology and learning has been generally defined in policy documents and by educational researchers.

1.2. How has "21st century skills, technology and learning" been defined in educational policy and research?

This is a new century, with new demands on education, including the intensive and extensive demands of moving from a print-based culture to a digital culture, continued massification of education in general, and the pressing need for global competitiveness in a post-industrial, knowledge-based economy. Twenty-first century learning is broadly conceptualized as learning that is supported through and enabled by the use of the broad range of Information and Communications Technologies (ICT) that are an increasing part of everyday life, such as those for communication, social networking, and even surveillance. Generally, 21st century learning signals an integrated approach to skills, technology and learning that recognizes that computer-based devices are a central and critical part of contemporary life and that knowledge of them is key to both education and employment.

Specifically, these skills include, and are referred to as the "4 Cs" (ISTE, 2007; OECD, 2009; Partnership for 21st Century Skills, 2009):

- Creativity and Innovation;

[1] Please see Appendix A: Methodology for a description of our process in scanning, compiling and analyzing literature around 21st century skills, technology and learning.

- Communication;
- Critical Thinking and Problem Solving; and
- Collaboration.

These are viewed as skills that are required to live, function in and contribute to a 21st century "knowledge society", and as such cut across conventional subject areas. They are not always or necessarily ICT-dependent (Annetta et al., 2010; OECD, 2009). The core issue remains that however defined, 21st century skills are deemed necessary to work, live and learn today. For the purposes of this report, ICT are understood as key to teaching and learning today.

1.3. Trends and themes: An overview

In addition to ICT-enabled curriculum and teacher professional development to support teaching and learning in a 21st century context[2], a number of other trends and themes can be identified from research published since 2005. Here we offer a brief overview of the trends and themes of particular relevance to current educational reform.

The trends listed here are not related to the use of *specific* technologies in support of teaching and learning, but are rather broader developments across educational contexts. Each involves and engages a range of different ICT.

Trend 1: Open source technologies
There is an ongoing shift at the level of many classrooms, boards, and in some cases districts, towards open source, open-access technologies as cost-saving measures. This movement also tends to include opening up previously closed networks so students can connect their own devices to school-based intranet and wireless networks.

Trend 2: Adaptive and assistive technologies
One of the most significant and noticeable applications of ICT in classrooms has been in the use of adaptive and assistive technologies to support differently-abled students. In fact, research in this area provides one of the clearest links between ICT use and student achievement.

Trend 3: Engaging parents
Educators and educational administrators are turning to the internet, cell phones, and other technologies to increase parental engagement, allow for closer parental contact with teachers, and encourage teacher involvement in the everyday lives of their students.

Along with these trends, this report also addresses ongoing issues and *significant*

[2] For an overview of how curriculum and teacher professional development are viewed inter-jurisdictionally through policy, see Appendix B: Interim Report.

silences in the research that we examined with regards to ICT in support of 21st century learning.

Theme 1: Digital naifs?
There continues to be in much of the research we examined a careless and under-theorized use of the term 'digital native' to signal ubiquitous student understanding of all things digital. Cutting through this rhetoric, many studies point to the 'digital divides' that still persist in ICT use, between male and female students as well as teachers; between students in urban and rural settings; and between relatively affluent student populations and those less fortunate.

Theme 2: Computers in schools - (still) underused
There is an ongoing but under-reported disconnect between the massive spending devoted to digital technologies in schools, and their persistent under-use in classrooms, despite claims that the 'next gen' of tech-savvy educators are more inclined to integrate technologies into their teaching.

Theme 3: Environmental impact of ICT
This report addresses a significant silence in both policy frameworks and guidelines in ubiquitous computing programs (for instance, 1:1 device initiatives), as well as in related research: the absence of policies and practices that carefully and meaningfully address the environmental impact and sustainability of ICT in schools (e.g. how computers are recycled and what are the hidden costs to the environment to their wide-scale, ongoing use)

1.4. Student achievement and instructional practice: An overview

In this section, we summarize research on the impacts of 21st century skills, technology and learning on student achievement and instructional practice, and acknowledging the challenges of assessing these impacts. We address the lack of direct evidence at a macro-scale[3] (within or across jurisdictions) that links ICT integration to more effective instructional practice and/or higher student achievement, and we consider some of the reasons why we lack evidence. One such reason is that because technologies are utilized as just one of many tools for teaching and learning, their effects on student achievement are often difficult to isolate and measure. As well, standardized assessments of conventionally-conceived learning outcomes often do not ask, or indeed enable, students to deploy ICT-related skills. As a result, improvements in student achievement attributable to educational uses of ICT may be present but not yet identified or measured.

Having said that, there *is* contextual and persuasive evidence, on a smaller scale, that links student achievement to technology use. More often though, the localized and small-scale projects we compiled and analyzed link ICT to *student engagement* rather

[3] By macro-scale research, we mean studies that collect evidence and report on the state of education at a jurisdictional level.

than achievement. There is an increasing recognition that educators and schools need to employ digital technologies, not because there is necessarily a link to traditional forms of how student achievement is measured, but because technologies are increasingly a part of children's lives in a 21st century society.

At the level of instructional practice, the integration of 21st century skills, technology and learning has not yet been addressed in a systematic way in either pre-service or in-service teacher education. Numerous studies identify this as one primary reason for the ongoing under-use of ICT in schools.

Section 2: What are the major themes and trends in relation to 21st century skills, technology and learning?

This section examines the themes and trends we identified as being particularly relevant to 21st century skills, technology and learning. Rather than focus this overview on the specific emerging technologies that are receiving a lot of attention in formal education at the moment, we identify the more comprehensive themes and trends that cut across efforts at educational reform at all levels, from classroom to district to jurisdiction.

2.1. Open source technologies

California's recent decision to implement open source textbooks is the latest widely-publicized development in the debate around whether, how and to what extent schools can and should adopt open source technologies (Timmer, 2009).

The driving motivation behind California's decision is the lower costs associated with open source textbooks compared to conventional textbooks. Advocates of open source technology in education,[4] however, point to pedagogical as well as economic benefits: students have access to a growing repertoire of specialized, context-specific applications to support individuated and independent learning (Derringer, 2009; Hebpurn & Buley, 2006; Marson, 2006; Pfaffman, 2008), and can become involved in an emerging 'prosumer' culture of collaborative knowledge-sharing (Araya, 2008).

Detractors point to the hidden costs of open source software, the perceived lack of technical support in comparison with proprietary software, the (current) lack of curriculum-approved resources (Derringer, 2009), and the related perception that *because* they are 'open', they are somehow less legitimate (de Castell & Jenson, forthcoming).

Several studies suggest that these concerns will be alleviated, and the barriers to further adoption of open source, open access tools removed, as the economic benefits become more apparent, particularly in times of fiscal hardship (Marson, 2006; Pfaffman, 2008), and as technology administrators in schools and districts become more comfortable with the quality and reliability of resources (Derringer, 2009). The drive to adopt open source resources has been given an added push in North America by the US Department of Education's most recent (2010) *National Educational Technology Plan*, which calls on K-12 schools to follow the lead of higher education in embracing open source software for administration, instruction, and learning (p. 57).

[4] Organizations advocating for—and providing—open source software for K-12 schools include K-12OpenSource.com (at http://www.k12opensource.com/) and the Consortium for School Networking (CoSN)'s K-12 Open Technologies (at http://www.k12opentech.org/).

2.2. Assistive and adaptive technologies

One area of research that does demonstrate a direct impact of technology on student achievement[5] is in the support of students with learning disabilities. Assistive technologies utilized by these students are devices meant to scaffold students' learning (Marino, Sameshima & Beecher, 2009), and include screen readers, speech-to-text software, and technology-based scaffolds, such as digital outlines of text or question prompts embedded in technology-based interfaces. Such devices can maximize educational opportunities for differently-abled students by promoting access and participation while also improving learning outcomes (Alper & Raharinirina, 2006; Michaels, Rose, Meyer, & Hitchcock, 2005). Numerous studies with this student population have concluded that assistive technologies have had positive effects on learning outcomes (Lange, McPhillips, Mulhern, & Wylie, 2006; Okolo, 2005), critical thinking skills (Twyman & Tindal, 2006), motivation (Lange, Mulhern & Wylie, 2009), and test-taking strategies (Lancaster, Lancaster, Schumaker, & Deshler, 2006). Moreover, assistive technologies can mediate students' performance through question prompts, writing scaffolds, and procedural steps that lead to a strategic plan for accomplishing goals and objectives (Englert, Wu, & Zhao, 2005). The use and integration of tools such as screen readers and speech-to-text software (and even more unconventional tools like video games and online 'virtual' worlds; see Cheng & Ye, 2010) in education is critical to providing *all* students with the knowledge and skills necessary for active and successful participation in their schooling, as well as in both the local and global communities.

2.3. Engaging parents

Establishing greater opportunities for parental involvement in student learning through ICT is an emerging but significant trend in the inter-jurisdictional scan of policy we completed (see Appendix B: Interim Report). Effective parental involvement is regarded as having a positive impact on a range of student-related outcomes. Harris and Goodall (2008) conclude that home-based, rather than school-based, involvement in supporting learning has the greatest impact and that schools need to provide "guidance and support which enable such engagement to take place" (p. 286). For some educational jurisdictions, this has meant explicitly designing ICT related policies[6] to mobilize and support parental engagement.

Providing and encouraging parental access to teaching and learning resources is framed as a way of enabling "anytime-anywhere" student instruction, and of extending formal learning beyond the classroom. For example, Hong Kong's education

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[5] Please see Section 3: What (if any) are the impacts of skills, technology and learning on student achievement and instructional practices?

[6] For example, see England's *The Children's Plan* (2007) and Hong Kong's *Third Strategy on IT in Education* (2008).

system positions parents as essential role models and exemplars of 21st century learning. The parent's section of Hong Kong's primary education portal contains learning resources for parents to educate their children and to become ICT-literate themselves. Hong Kong's rationale is that if students see their parents engaging with technologies for learning at home in their leisure time, this will cultivate a view of learning as a life-long process.

Parents are also implicated in attempts to improve and extend ICT-based mechanisms for tracking student progress and, increasingly, student behaviour and attendance. In England, for instance, Becta's policy document *Harnessing Technology Funding 2010-2011: Guidance for Schools* (2009) encourages schools to invest funding in developing technology-based parental reporting systems utilizing management information systems, learning platforms, managed learning environments, messaging services or other suitable online reporting systems. This initiative is viewed as a means to ensure a strong parental voice in the education system.

However, providing technology and connectivity will not necessarily result in improved parental engagement and/or involvement in their child(ren)'s education. Parents, like teachers in classrooms, require support and effective communication about the best ways to engage with their children's learning at home. While the provision of computers and connectivity in the home can increase parental involvement in their children's education, the challenge of how to engage *all* parents universally and how to sustain such engagement remains (Harris & Goodall, 2008).

The next three subsections focus on issues and themes identified as particularly relevant to educational reform in relation to 21st century skills, technology, and learning. These issues are:

- the ongoing tendency to (mis)label the current generation of children (and, increasingly, pre-service teachers) as 'digital natives', ascribing to an entire generation the ICT-related competencies and abilities of a relatively small number of socio-economically advantaged students;
- the underutilization of computers in schools, and the factors (some persistent, some relatively recent) contributing to this ongoing disconnect between investment in ICT and its consistent and pedagogically relevant integration into teaching and learning;
- the lack of attention in macro-level policy reform to issues around environmental sustainability with regards to the ongoing and massive investments in ICT hardware for education.

2.4. Digital naifs?

In the early 2000's a series of startling claims were made regarding the 'new'

generation of students that were entering educational institutions as 'digital natives'[7] (Frand, 2000; Oblinger & Oblinger, 2005; Prensky, 2001; Tapscott, 1999). A common theme in this literature is that young people's use of ICT is so pervasive and integral to their everyday lives that the education system must be responsive to the changed learning preferences of this group—on the premise that, generically, this is the first generation that has never known a world without digital technologies, it is asserted that digitally-'native' students' immersion in the technology-rich culture of the 21st century has caused them to learn and communicate differently compared with past generations. From this view, the digital native generation is seen as active experiential learners, proficient in multitasking, and dependent on digital technologies for accessing information and interacting with others.

Many education researchers have scrutinized these claims about today's students, pointing out that they have been put forward without theoretically-informed research and sound, empirical evidence to substantiate the sweeping generalizations made (Bennett, Maton, & Kervin, 2008; de Castell, Boshman, & Jenson, 2009; Guo, Dobson, & Petrina, 2008; Li & Ranieri, 2010; Sanchez, Salinas, Contreras, Meyer, 2010). These critics argue that the 'digital native' claims are based on limited empirical evidence (e.g. Tapscott, 1999) and supported anecdotally or by appeal to common-sense beliefs (e.g. Prensky, 2001). Critics further argue that the "digital native" view positions birth year as the key determinant of whether a person will be technologically adept, and overlooks other major factors that would influence one's level of technological competence, including cultural practices, socio-economic status, geographic location, and gender.

Critics have charged that the "digital native" argument has induced an academic moral panic in the education community, which demands total and rapid educational reform to avoid further failures on the system's part to properly 'engage' this new generation. Further contributing to the moral panic is the dramatic language of the "digital natives" argument that presents a series of dramatic dichotomies known as 'digital divides': between the 'digital natives' and the 'digital immigrants' (previous generations of learners), between the technically adept and those who are not, and between '21st century' learners and a culturally-obsolescent education system. Interestingly, advocates of this view do not reflect upon the series of digital divides that can be observed *within* the so-called "digital native" generation which include divides between urban and rural student populations, between male and female students, and between poor and affluent student populations (Livingstone, Bober, Helsper, 2005; Schulmeister, 2009).

These internal divides are explored by more rigorous research that closely scrutinizes the assumptions made of today's students and their ICT use. This second wave of research shows that ICT is socially distributed in such a way that these "digital

[7] A host of terms were coined and used to describe this new learner (e.g. digital natives, millennials, net generation, generation C, generation G), however 'digital native' is the most widely used and accepted.

native" traits are specific to socio-economically advantaged populations. It shows, too, that digital competence is more determined by the cultural practices of such groups than by generational effect (Sanchez, Salinas, Contreras, Meyer, 2010). Furthermore, some researchers argue that the competencies of "digital natives" is overstated: they are not necessarily knowledgeable about or skillful in using digital tools, especially when they are in learning situations (de Castell, Boschman, & Jenson, 2009; Kennedy, Judd, Churchward & Gray, 2008). For instance, a study conducted by Li and Ranieri (2010) found that students' *familiarity* with ICT was not an indication of whether they were able to use school-related ICT *competently*. Students' use of everyday ICT (for socializing and entertainment purposes), for example, does not necessarily transfer over into skillful use of ICT for learning.

It is undeniable that the expectations for today's students are different. Students are expected to develop and master a new (and evolving) skill set that includes, at minimum, a basic level of digital competency to be successful in a globalized economy. While we want all students to master this skill set by the time they leave the system, the diversity of their everyday experiences with ICT means that they do not all start from the same place. What needs to be made clear is that *not all students are 'digitally native'*. This term denotes a privileged position in terms of gender, socio-economic status, and geography. Therefore, the role of ICT in the classrooms, in context of 21st century skills, technology and learning, is arguably about providing access and scaffolding to students, and thereby creating educationally equitable and socially just teaching and learning environments.

2.5. Computers in schools: (Still) underused

Almost a decade since the 2001 publication of *Oversold and Underused: Computers in the Classroom*, Larry Cuban's study of computer integration in Californian schools, research in the area of technology-enabled instruction continues to point to the same fundamental issue. Despite massive investment in digital technologies for education over the last two decades, there remains little evidence of its impact on student achievement. As well, the research consulted for this report points to inconsistent, uneven and inconsequential implementation of ICT to advance the teaching and learning of 21st century skills. Research in Canada, Denmark, England, the US, and elsewhere consistently reports the following findings, initially cited by Cuban in 2001:

- Technology continues to be primarily used for educational administration rather than instruction;
- There is little systematic implementation of meaningful and rigorous professional development in relation to ICT-based instruction, either for pre-service or in-service teachers;
- There are few accountability measures for reporting on teachers' efforts (or lack thereof) to integrate ICT into their instruction (significant exceptions include the STaR system in Texas, and the ICT self-assessment tool for teachers in England);

- Educators remain under-supported in their efforts, with little preparation time and on-site technical support for integrating ICT into their practice (Becta, 2010; Culp, Honey & Mandinach, 2005; Denmark Ministry of Education, n.d.; Jenson, Brushwood Rose, & Lewis, 2007; Robinson & Sebba, 2010; US Department of Education, 2010; Whale, 2006).

Case studies on small, localized efforts to integrate ICT into instructional practice and learning report further barriers:

- ICT (particularly computers) continues to be clustered in computer labs and libraries, meaning that access is still an issue, even though the technology is ostensibly available (Fragkouli & Hammond, 2007; Hixon & Buckenmeyer, 2009; Johnson & Maddux, 2008; Hammond et al., 2009).

These and other studies collectively depict the material conditions of technology (dis)use in formal K-12 education, where digital technologies are very much in schools, but very infrequently in pedagogical practice. While 'good news stories' abound in regards to students and teachers using digital technologies in innovative and educationally significant ways, the overall context remains that of substantial, persistent and complex barriers to the consistent implementation and recognition of ICT-enabled teaching and learning.

2.6. Environmental Impact of ICT

There has been little research to date on the impact of the large-scale purchasing of technology for K-12 education. In early work on the subject by C. A. Bowers (2000), *Let Them Eat Data: How Computers Affect Education, Cultural Diversity, and the Prospects of Ecological Sustainability,* the author argues that there is general disregard in uses of computers in education and their impact on the environment. The important point in that work, and one thing that is still radically under-discussed, is the ways in which ICT impact the environment, including not just their daily costs in terms of electricity use, but also their cost to recycle and/or destroy. To illustrate by way of one small example: it is useful to ask, how many school districts and/or provinces have tried to reduce costs and environmental footprints of ICT in schools by requiring they be shut down when not in use or at the end of the day? In our literature review and in our inter-jurisdictional scan we did not find a *single example* of policy that explicitly tackled the issue. Disposing of computers, monitors, and computer-based equipment also has an enormous impact on the environment, yet in no literature we consulted was this considered when equipment was being purchased for educational use. It is imperative in the future that the environmental costs versus benefits of ICT are not only discussed, but directly addressed through educational policies. That they are not discussed and are absent in policy to date, contradicts 21st century skills, technology and learning goals, and seems to be one area that could very much be developed to produce leading-edge educational policies.

Section 3: What (if any) are the impacts of skills, technology and learning on student achievement and instructional practices?

This section addresses the impact of skills, technology and learning first on student achievement, and then on instructional practice, separating the two in order to afford a more nuanced look at how they are articulated within ICT-enabled education.

3.1. Student achievement: missing the mark

The impact of 21st century skills, technology and learning on student achievement is difficult to measure as the landscape of schools and individual classrooms is so varied, and as digital technology remediates the form and function of public education. In the literature reviewed, there is a notable lack of evidence that directly links 21st century skills, technology and learning to increased student achievement. Two distinct but related reasons explain the absence of evidence. First, on a macro-scale, standardized assessments are simply not capable of either evaluating or reporting on the elements that reflect students' achievement of 21st century skills (communication, collaboration, creativity and innovation, and critical thinking). Second, at the level of individual boards and classrooms, indications of increased student achievement in relation to 21st century skills, technology and learning are less recognized, monitored and assessed than indications of student engagement.

A macro perspective on student achievement

Student achievement is measured on the macro-scale (e.g. all students in the public school system) through standardized testing. Nearly universally, such testing focuses on measuring competencies in mathematics, sciences, and paper and pencil 'literacies', but leaves out ICT competencies, and/or forms of collaborative knowledge production. This means that as presently structured and implemented, standardized assessment processes are not capable of evaluating the skills and competencies associated with 21st century learning. This critique emerged as a strong theme through our scan of academic literature and governmental policy documents, and was echoed by policy-guiding think-tanks like the International Society for Technology in Education (ISTE) and the Partnership for 21st Century Skills (P21).

In addition, standardized evaluation tends to come into tension with the broad characterization of work and learning in the 21st century as by necessity *collaborative*. Evaluation tends to measure students' individual understandings and competencies, not their abilities to learn, work and produce collaboratively. In other words, standardized testing is necessarily results-driven and individuated, while collaboration tends to be process-driven and group-oriented.

ICT and student achievement

Consistently across all the research reviewed for this report, ICT-based education was viewed as a cornerstone of 21st century skills, technology and learning, and yet larger-scale studies have consistently found "no significant results" from the integration of

ICT on students' assessment scores.

For example, a multi-site study of ten 1:1 laptop programs in the U.S. found that while significant changes were made to the "processes, sources and products of literacy", and students showed significant gains in technology-related literacies, there was no impact on tests scores or on the achievement gap (Warschauer, 2008). Another large scale, multi-site study of a virtual environment for scientific inquiry, involving 2,000 students, reported little difference between the control and the test group using a standardized post-survey. When the researchers altered their method of assessment, they found that the test group showed a "stronger understanding of scientific inquiry" (Ketelhut, et al., 2010, p. 67). Employing a different tactic, Lei (2009) argues that too many studies of ICT in relation to student achievement focus on the *frequency* of students' technology use (e.g., "computer time") rather than the quality of instruction and integration, or the types of technologies used in relation to specific subject areas, or how and for what purposes technology is used. With this methodological shift in place, Lei's own study connects specific technologies to specific and significant outcomes related to technological proficiency, learning habits and emotional development, but observes that *assessment scores* (e.g. post tests) were not affected.

As suggested by Lei (2009) and argued more decisively by Lui, Maddox and Johnson, (2008), there is a major weakness in the research that finds "no significant results". This weakness is that it is based on a flawed premise —namely, the assumption that providing access to technologies is, in itself, beneficial. This conceptual pitfall is best summarized by the editors of a special issue of the National Technology Leadership Coalition, who conclude:

> Research questions and designs that fail to differentiate by the content being studied, the pedagogical strategies employed and the way technology interoperates with these variables will probably continue to find that merely using a technology medium is not educationally beneficial (Schrum et al., 2007).

Ground-level ICT integration and student achievement

There is some evidence to show that the use of ICT to support teaching improves student achievement. Research on the use of interactive white boards (IWBs) in English language learning showed improved standardized test scores (López, 2009). Another study showed that students' whole word recognition was improved through teachers' use of multimedia software (Karemaker, Pitchford, O'Malley, 2009). Still another study claimed that the use of "GroupScribbles" brainstorming software in a science classroom helped foster collaboration, participation and increased achievement in traditional classroom-based assessments (Looi, Chen, & Ng, 2010). Using a control group methodology, a large-scale study of a socially-networked online environment found that when the educators/researchers changed their assessment procedures so that students had to complete a "lab report", a direct impact from ICT use was shown. However, traditional assessment methods showed no impact (Ketelhut, et al., 2010).

These and other classroom level case studies point to positive relationships between ICT-based education and student achievement, but they remain highly context-specific, with limited scalability. They are useful, however, in that they collectively represent an exploration of the educative potentials of digital technologies applied to specific sets of outcomes and subject areas.

There remains, however, a significant disconnect between standardized assessments and the kinds of competencies, skills and dispositions flagged by 21st century skills, technology and learning that are being cultivated through the grass-roots level practices reported in these case stories. An ongoing challenge is to re-tool assessment methodologies and practices in order to account for how ICT *transform* teaching and learning. In addition, the effectiveness of technology use need not necessarily be contingent on specific achievement-related student outcomes. Outcomes that are also important components of schooling include student behaviours, attitudes, self-esteem, digital literacies and career aspirations. However, it continues to be the case that improvements to student achievement attributable to educational uses of ICT may be present, but are not yet identified nor properly measured.

In the next section, we turn to a discussion of one highly significant outcome that is strongly represented in literature on 21st century skills, technology and learning: the capacity of digital technologies to increase student engagement in classroom-based learning.

Technology and student engagement: a not-insignificant outcome
In contrast to the difficulties in assessing student achievement and technology use, student engagement using technologies has been well documented. These studies tend to focus on the use of one kind of technology such as: an interactive white board (Beauchamp & Kennewell, 2010; Torff & Tirotta, 2010), game (Carbonaro, et al., 2008; Owston, et al., 2009, Whelchel, 2007), multimedia program, 1:1 laptop program (Lei, Conway & Zhao, 2008; Penuel, 2006; Warschauer 2008), or an iPod touch (Auchincloss & McIntyre, 2008). While they can be large in number, they tend to have limited scope, both because of context and because of implementation factors. As well, because of the lack of longitudinal studies, it is difficult to assess whether or not engagement and motivation hold over time, although recent evidence suggests they might (Lei, 2010).

There are many other examples of technology being used to ignite and support student engagement—from multimedia projects with clickers to students creating near-professional documentary style video-based productions. Some of these, such as the National Film Board of Canada's annual competition on Racism means that students receive national recognition for their amateur film efforts. The fact that technology is, for many (but by no means all) youth, pervasive in their lives in some format, means that they are beginning to demand that presence in their everyday lives in schools. Sheehy and Bucknall (2008), for instance, describe a multi-age study

of students' visions of the future in which, at all age levels, technology figures prominently.

These studies are useful, once again, in demonstrating the extent to which the question 'how do technologies impact student achievement?' might be misleading. Clearly, better performance on standardized achievement scores is only one of a number of outcomes that matter from the perspective of 21st century skills, technology and learning. This is particularly the case since the inadequacies of standardized assessments for measuring ICT-enabled skills have been recognized for almost 20 years.

3.2. Instructional practice

This section addresses the disconnect, identified in both academic literature and policy documents, between the availability of technology in schools and their integration in instructional practice. This is widely regarded as a significant barrier to the realization of 21st century teaching and learning and to the deployment of technologies that account for massive funding, infrastructure and policy efforts. There is consensus that the use of ICT can enable a differentiated approach to instruction, and that there is a real need for transformative teacher practices that moves from instructing to facilitating. In response, the research here reviewed is concerned with re-conceptualizating teacher training, at both the in-service and pre-service levels, to address the disconnect between technology availability and its effective integration.

Pre-service technology training
A number of studies cite "*Will new teachers be prepared to teach in a digital age? A national survey on information technology in teacher education*" (1999), a study that led to the formation of NETS global standards (Kay, 2006; Thieman, 2008; Williams, Foulger & Wietzel, 2009). In this study, Moursund and Beilefeldt (1999) state that 71% of teacher education programs surveyed in the report required at least three hours of "generic instruction" in ICT, but did not offer adequate instruction into how ICT can improve instructional practice. The study also found that in their co-operative placements, pre-service teachers rarely worked collaboratively with teachers / supervisors in developing ICT-based instruction.

A few studies position the new generation of pre-service teachers as 'millenials' or 'digital natives' (Heo, 2009; Lambert & Cruper, 2008; Lock, 2009; Marks, 2010), but make the point that even where student teachers exhibit greater technology use than previous generations, this by no means translates to the ability to effectively integrate ICT into instructional practice. Several studies suggest that a decade on from Moursund and Beilefeldt's report it is still the case that few teacher colleges offer anything more than cursory technology skills training (Hall, 2006; Johnson & Maddux, 2008; Kay, 2006; Lambert & Cuper, 2008; Lambert & Gong, 2010; Russell, Bebell, O'Dwyer,& O'Connor, 2003; Thieman, 2008; Whale, 2006; Vockley, 2008).

Speaking to the US context, Lambert and Gong (2010) point out that "the stand-alone educational technology course still serves as the primary means of pre-service teacher preparation in technology" (p. 55).

These studies address the perceived *ongoing* disconnect between the lack of adequate, large-scale pre-service teacher training, and the needs and expectations of 21st century learners for whom digital technologies are increasingly ubiquitous. The majority of these reports are case studies of reforms made in individual teacher training classes. These studies provide empirical evidence that link intensive, deliberate and sustained pre-service technology training to teachers' effective integration of ICT in their instructional practice. Often (Hall, 2010; Lambert & Gong, 2010; Thieman, 2008; Williams, Foulger & Wetzel, 2009) the emphasis in these projects is on expanding the scope of pre-service training in order to not only train teachers in specific ICT, but increase teachers' self-efficacy and confidence in technology-based instructional practice, and demonstrate the relevance and applications of specific technologies to 21st century skills and learning.

Methodologies

The majority of studies reporting on efforts at reforming teacher training programs, either at the level of individual teacher college courses and programs or at a national level, in the case of Coklar and Odabasi's report on Turkey, measured their findings against ISTE's National Educational Technology Standards (NETS) frameworks. Initially published in 2000 and updated most recently in 2008, the National Education Technology Standards for Teachers (NETS-T) identify a series of expectations for teachers in relation to technology-enhanced instruction. These frameworks provide performance indicators for both teachers (NETS-T) and students (NETS-S) for ICT-based instruction and learning. In doing so, these reports explicitly measure study outcomes against an internationally recognized set of definitions as to what 21st century skills, technology, learning and teaching involve (see, for example, Banister & Vannata, 2006; Basham, Smeltzer & Pianfetti, 2005; Hall, 2006; Stuve & Cassady, 2005; Williams, Foulger, & Wetzel, 2009).

Gender

A smaller number of studies related to pre-service teacher training and 21st century skills, technology and learning address a gender gap in student teachers' ability and willingness to integrate ICT into their instructional practice. Sang, Valcke, von Braak and Tondeur (2009) use self-report measures from Taiwanese student teachers to assess whether and how gender is a predictor of "prospective ICT use", finding no significant gender differences. Similarly, in their case study of a teacher training course oriented around 21st century skills, Lambert and Gong (2009) found no discernable gender gap in participants' levels of anxiety and self-efficacy related to ICT use, either before or after the course. As with other case studies of teacher training courses and programs, these studies rely primarily on self-reported accounts from students enrolled in a course where the instructors are also the researchers.

It certainly remains the case that girls, and later women, do not choose higher education or careers that are computer-science or engineering focused. In fact, a recent study of North American enrolment rates for young women in computer science and engineering showed *decreased enrollment* over the past 25 years in these areas, stating "by graduation, men outnumber women in nearly every science and engineering field, and in some, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20 percent of bachelor's degrees. Women's representation in science and engineering declines further at the graduate level and yet again in the transition to the workplace" (Hill, Corbett, & Rose, 2010, p.15).

Technology, especially computer-based technology is still very much, at least in terms of skills and careers, occupied by many more men than women (c.f. Hill, Corbett, & Rose, 2010; Anderson, Lankshear, Timms & Courtney, 2008; Anderson, Timms, Courtney & Lankshear, 2008; Lasen, 2009).

In-service technology training

Although most of the literature reviewed on instructional practice and ICT focuses on pre-service technology training, a number of studies explore efforts at 'skilling up' in-service teachers on effective ICT-based instructional practice. As reported by Fragkouli and Hammond (2007) and Hammond et al (2009), even educators who are well-prepared by their pre-service education face significant barriers (curricular constraints, constraints around access, lack of technical support and preparation time) to integrate ICT into their instructional practice. A related issue regarding in-service professional development is the fact that 81% of school districts surveyed in the USA do not include technology skills in teacher evaluations, and that where such evaluation is in place, expectations are often vague and indistinct (Whale, 2006, p. 71).

Many studies of in-service ICT-oriented professional development report on small-scale attempts at implementing particular programs. Of these, the majority are concerned with instructional practice in mathematics and the sciences. Valanides and Angeli (2008), for instance, an increase in science educators' use of computers in their instruction after intensive workshops focusing on modeling multimedia-based instructional strategies.

Other studies focus less on particular subject areas and more on the uses of certain digital technologies across curricula. Conole and Culver (2009) describe how a social networking tool for in-service teachers helped facilitate collaboration and knowledge-sharing among users. Beech, VanOverbeke, and Bonnstetter (2009) provide a more generalized survey of how in-service teachers can integrate technologies from games and puzzles, to PowerPoint, to digital cameras, in keeping with NETS-T standards.

Section 4: Conclusion

This report has addressed two questions central to educational reform in the 21st century:

1) What are the major themes and trends in relation to 21st century skills, technology and learning?
2) What (if any) are the impacts of skills, technology and learning on student achievement and instructional practices?

It has approached these questions by providing a preliminary framework for conceptualizing 21st century skills, technology and learning. It identifies instances where 21st century skills have been specifically articulated, and dismisses the ongoing characterization of an entire generation of students as 'digitally native'. In doing so, it steps aside of much of the rhetoric surrounding current educational reform. Rather than report on technologies that are at the moment getting a lot of attention, we have identified *higher-order* trends, each engaging a range of ICT, that cut across educational reform at both the macro-scale and grassroots level.

Summary of Findings

This report has addressed the challenges facing educational reform in the 21st century. Some are persistent (the ongoing gender gap in ICT-based teaching and learning, and the troubling disconnect between spending on ICT and its actual use), and some emergent (the need for educators and policy-makers to take seriously issues around sustainability with regards to ICT and the push by students to use digital devices for and in their daily school routines). These challenges demand, more than ever, educational reform built around the principles of inclusivity, equitable access, and the *meaningful* integration of ICT into teaching and learning. Moreover, this report recognizes that the outcomes and impacts of such reform cannot be measured by conventional modes of standardized testing. Rather, the 21st century skills and learning made possible by new technologies represent a fundamental challenge to the individuated yet homogenizing systems for assessing and measuring learning that are currently in place.

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Appendix A: Methodology

For this report, we consulted hard and soft policy documents from numerous jurisdictions (particularly, but not limited to, those we focused on in the Interim Report; see Appendix B). We also drew from large-scale reports published by policy-guiding organizations regarding 21st century skills, technology and learning, and the role of ICT. These works (OECD report, ISTE, P21) provided touchstones for articulating the commonalities across different uses and applications of "21st century skills, technology and learning".

Building on this base of information, we undertook a comprehensive scan of academic literature organized around 21st century skills, technology and learning, and ICT-enabled instruction and education. These were the steps followed: We proceeded by conducting preliminary sweeps of academic journals related to professional development and teacher training, technology-enhanced learning, educational administration, ICT use in schools, assessment/achievement and ICT use, and curriculum implementation supported by ICT. With this initial overview in place, we generated a list of the themes and issues we found particularly relevant, salient, and/or significant with regards to the two questions addressed in this report, and with those issues and themes in place, we went back into the literature to conduct a more focused compilation and analysis of articles.

In total, the initial scan produced over 500 academic journal articles and books from 2005 until the present, with back checking of older work where relevant. These we narrowed down to salient works that directly addressed the two primary questions this report focuses on:

1) What are the major themes and trends in relation to 21st century skills, technology and learning?
2) What (if any) are the impacts of skills, technology and learning on student achievement and instructional practices?

Appendix B: Interim Report

This report was submitted on June 4, 2010, in response to the question, "What are the Ministry's comparator jurisdictions doing on skills, technology and learning and what theoretical perspectives inform their work?"

The executive summary and report have been reproduced from the original, excluding appendices.

Section 1: Executive Summary
1.1. Introduction

"Twenty-first century skills, technology and learning" is a common phrase that is in use both in educational policy documents and in popular media to signal, first and foremost, *change*. This is a new century, with new demands on education, including the intensive and extensive demands of moving from a print-based culture to a digital culture, continued massification of education in general, and the pressing need for global competitiveness in a post-industrial, knowledge-based economy. This report responds to the question of how educational jurisdictions outside of Ontario are addressing new demands for global competitiveness, 21st century job training, pervasive and responsive technologies, connectivity, and educational uses of mobile technologies, social networking and games.

Fifteen jurisdictions implementing whole-scale system reform were examined for this report[8]—Alberta, British Columbia, California, Catalonia (Spain), Denmark, England, Georgia (US), Hong Kong, Maine, New York, Norway, Singapore, Tennessee, Texas, Victoria (Australia)—and a thorough policy scan of government websites, documentation and commissioned reports, related web materials, educationally focused-websites, school-level websites and reporting structures, media releases, and news and journal-related media. With four exceptions (California, Denmark, Tennessee, and British Columbia), each of the jurisdictions outlined, through policy documents and/or related literature, and a vision for "skills, technology and learning" that was supported both fiscally and through related policy-driven curriculum documents and professional development opportunities for teachers.

While policy-driven, technology-enabled, whole scale system reform is common to almost all of the jurisdictions that we examined, there was wide variability in how that was implemented. For the purposes of this report, we have attempted to capture that variability through short overviews of each of the fifteen jurisdictions (see Section 2: Overview), as well as in the more in depth 3-page reports we have prepared (Appendices E to T).

[8] Please see Appendix A: Methodology for a description of how we selected and analyzed each comparator jurisdiction.

Variability not withstanding, there were three common themes in regards to ICT that cut across all jurisdictions that we examined:

- Every jurisdiction provides funding for ICT;
- Every jurisdiction provides ICT-focused professional development for teachers;
- Every jurisdiction embeds ICT in the curriculum, across subject areas and grade levels.

What is significant here is that there seems to be little or no question that the role of education is to be responsive to the demands of the 21st century, which include information and communications technologies. Having said that, there is tremendous variability in how educational policy in each jurisdiction addresses these concerns through funding, school accountability, teacher training and professional development, and curriculum.

1.2. 21st Century Skills, Technology and Learning

21st century learning is broadly conceptualized as learning that is supported, enabled and makes use of the broad range of technologies that are a part of 21st century life, such as those for communication, social networking, and even surveillance. Twenty-first century learning generally signals an integrated approach to skills, technology and learning that acknowledges that computer-based devices are a central and critical part of life, no matter where one is located and knowledge of them is key to both learning and jobs.

Many if not most of the jurisdictions we looked at tied 21st century skills, technology and learning to the need to support students' entry into a globalized knowledge economy. That is to say, technology was principally implicated not as a driver of educational change, but as a necessary part of life and learning in the 21st century. In other words, it was viewed as something that supports both instruction and learning, but was not viewed as the agent of change—that responsibility resides in all cases at the level of the classroom and the teacher, and is supported through top-down policy implementation.

So while there was ubiquitous support for ICT in education, it was also equally difficult to find evidence of the ways in which ICT were improving student achievement on a macro scale. Smaller studies (some anecdotal, some research-based) of single classrooms, schools, and districts, however, did attest to the fact that technology can support and guide student learning, if linked directly to and enabled by classroom instruction.

1.3. Key Findings

This review of comparator jurisdictions' educational policies with attention to skills, technology and learning focuses on six key categories for analysis. These categories represent the primary areas of concern in jurisdictions that are undergoing policy-driven, technology-enabled whole-scale system reform. They are:

- how education is **governed and funded** in each jurisdiction;
- the role of ICT in **school/district accountability and data management;**
- the role of ICT in **professional development**;
- ICT in relation to **student engagement and achievement**;
- ICT **embedded in the curriculum**; and
- the role of ICT in **parental communication and involvement.**

We explain each of these categories in more detail in the next section.

Governance and funding structures
Top-down educational policy is enacted most clearly through funding. In every jurisdiction we examined, specific funding is earmarked for ICT in schools, whether administered to schools or districts/boards through formula funding, competitive grants, or a combination of the two. In almost all cases, funding for ICT is contingent upon local (school or district/board) technology plans, which must be approved at the jurisdictional level. This means that (with some notable exceptions), there is significant centralized control over the provision and integration of ICT for schools.

School/district accountability and data management
Computer technology plays a major role in the mechanisms that many of these jurisdictions put in place to collect, track and analyze data from schools. Centrally-run ICT-based accountability systems are used to collect standardized assessment scores, track individual student achievement, monitor the extent of ICT integration into teaching and learning, and track ongoing teacher professional development. Moreover, in most jurisdictions, student records are online and online systems for grade reporting are in place.

Professional development
All of the jurisdictions examined provide ICT-based teacher **professional development (PD)**. Teacher preparedness and willingness to integrate ICT into their practice in support of 21st century skills, technology and learning is identified as a fundamental policy goal. In a small number of jurisdictions we examined, ICT skills testing is a mandatory part of teacher certification. What is not clear, however, in any of the documents that were consulted for this scan or in any of the related grey literature, is whether and how PD drives changes in teacher practice, and what the relationship is between instructional innovation (with or without technologies) and student success.

Student engagement and achievement
In the hard policy documents and grey literature we analyzed, ICT was viewed in a number of different ways in relation to student engagement and achievement. In some cases, jurisdictions cited the increasing ubiquity of mobile, game-based and social technologies in students' lives as a rationale for embracing ICT-enabled educational reform. In other jurisdictions, students' *lack* of access, especially among socio-economically disadvantaged and rural populations, to what are now widely regarded as basic ICT and ICT competencies (e.g. internet access, personal

computing), are used an impetus for policy-driven integration of ICT into schools and classrooms. Finally, several jurisdictions viewed ICT as a means of providing differentiated and individualized instruction to students, and of thereby improving student achievement.

Curriculum
In all of the jurisdictions we examined, ICT-related skills are foundational elements of the curriculum. In some cases it is tied to particular subject areas, in others it is integrated across the curriculum. Almost all jurisdictions provide centralized portals for e-Learning resources.

While we cannot offer in this report a nuanced, on the ground account of how ICT are being integrated into classrooms in each jurisdiction we examined, we were able to discern a broad trend in the ways that jurisdictions approach ICT in relation to macro-level K-12 curricula. Unlike previous policy shifts in the late 1990's and early 2000's in which ICT-related skills were often identified as stand-alone curricular outcomes, ICT-related skills and applications are integrated across all subject areas, particularly language arts and sciences.

Parents
Establishing greater opportunities for parental involvement in student learning through ICT is an emerging but discernible trend across the jurisdictions we investigated. Providing and encouraging parental access to teaching and learning resources (such as online instructional materials or mobile devices) is framed as a way of enabling anytime, anywhere student instruction, and of extending formal learning beyond the classroom. Parents are also implicated in some jurisdictions' attempts to improve and extend ICT-based mechanisms for tracking student progress and, increasingly, student behaviour and attendance.

1.4. Ground-level, Grassroots Initiatives

In addition to the top-down initiatives and policies that broadly characterized skills, technology and learning, there were also ground-level, grassroots reforms that were reported on by local and sometimes national level journalism in nearly all of the jurisdictions we examined. These initiatives and the ways in which they were reported on usually had one thing in common: they highlighted the relationship between student learning and engagement and the use of some form of ICT either at the classroom or school level, and less typically at the school-district level. For example, a 1 to 1 laptop program in a classroom in California, an iPod touch and Nintendo DS program for math skills in a school in Bradford, England, or the purchasing of iPads as ebook readers for high schools in Santa Cruz, California. While these programs tend to get the attention of popular media, it is much more difficult to find research-based evidence that is tied to these kinds of projects. Such attempts often represent the most innovative approaches to skills, technology and learning but are rarely either sustainable over the long term or transferable from one context to another: they are *enabled* by policy but are not policy *driven*.

Section 2: Overview of Comparator Jurisdictions

This section provides a brief summary of each of the fifteen case stories provided in Appendices E to T for the jurisdictions examined. For each jurisdiction, a brief rationale as to why it was chosen (presented in italics) is given and we summarize our findings with regards to each of the four categories of analysis listed below. This overview illustrates the wide variability in the implementation of policy-driven, technology-enabled whole-scale system reforms across the fifteen jurisdictions examined.

The case stories provide documentary evidence in relation to four primary categories of analysis:

- Governance
- Funding
- Professional development and teacher training
- Curriculum

In addition, where explicitly mentioned either in hard or soft policy documents, parental roles and involvement are included.

Alberta

Alberta has pursued policy-driven, technology-enabled, whole-scale reform since 1996.

Educational governance in Alberta is hybridized: the Ministry of Education sets funding, standardized testing and curriculum, but local boards of education are authorized to determine local policies and practices. This allows school boards to use baseline government funding to address specific ICT needs and priorities.

Teachers in Alberta are not required to undergo ICT training as part of their certification. Province-wide professional development services offer in-service educators training for integrating ICT into classrooms, and enhancing technology leadership skills. *The ICT Program of Study* for K-12 students is a "curriculum within a curriculum" designed for integration across all subject areas.

British Columbia

British Columbia conceptualizes 21st century learning as technology-enabled and student-centered.

In a relatively decentralized system, B.C.'s Ministry of Education oversees educational policies in relation to standards and student performance, and local boards of education have authority to determine education policy, giving them autonomy and flexibility in the delivery of education services. Formula funding is provided to boards to manage their specific technology needs and priorities.

B.C. teachers are not required to undergo ICT training as part of their certification, nor are there any province-wide PD initiatives for in-service educators. ICT is integrated into subjects and can also be taken as specific courses in grades 8-12. Virtual schooling is central to B.C.'s approach to skills, technology and learning: all students can enroll in Distributed Learning courses through the LearnNowBC virtual school portal.

United States (U.S.)
The U.S. Department of Education emphasizes the importance of ICT-based education in preparing students for participation in a globalized 21st century economy.

The U.S. Department of Education is primarily responsible for establishing policy and monitoring federal funds for education, as well as conducting and publishing nation-wide research into public education. It also oversees conducting, compiling and reporting on states' adherence to the No Child Left Behind Act (NCLB).

Curriculum remains a state responsibility, although the NCLB mandates that states conduct standardized testing, allocate 25% of ICT-related funds to professional development, and administer a technology literacy requirement to Grade 8 students.

California
Regarded as a leader in ICT-based teaching and learning in the 1990's and early 2000's, California's education system has undergone significant budget cuts in recent years. The state has developed little policy in the area of skills, technology and learning.

The California Department of Education (CDE) sets all state policy and manages all funding that comes from the Federal government, through both formula funding and competitive grants.

California requires teachers to have ICT training for state certification, and offers a centralized self-reporting mechanism for ongoing ICT proficiency of practicing teachers. The CDE also offers voluntary ICT related PD opportunities for in-service teachers. ICT standards are integrated into California's curriculum.

Georgia (U.S.)
Georgia is involved in policy-driven, technology-enabled whole-scale system reform.

Governance of education in Georgia is centralized, driven by policy at the state level with school districts responsible for implementation and mandated to report back to the state through various accountability structures. Unlike most other states, which incorporate a combination of formula funding and competitive grants, funding for technology in Georgia's schools is provided entirely through competitive grants, and distributed through mandated and approved technology plans by district.

Until April 22nd, 2010, Georgia required teachers to have technology training for state teacher certification. The program reached over 70,000 educators and was rescinded due to cost and perceived lack of need. However, the state still offers ICT-related professional development opportunities for in-service teachers and leaders. Georgia's state curriculum integrates technology standards across all subject areas. Mandatory standardized testing at all grade levels focuses on student achievement.

Maine

In 2002, Maine began a 1 to 1 digital learning program that provided laptops and wireless classrooms to all 7th and 8th grade students and teachers. It initiated wide-scale technical assistance and professional development for administrators and teachers and integrated a research-based component in its 1 to 1 effort.

Maine's Department of Education sets all state policy and manages all funding that comes from the Federal government. In this centralized system, funding for technology for schools is formula-based and centrally distributed, and relies on both federal grants as well as state-legislated funding (through the Maine Learning Technology Initiative).

Maine does not require technological proficiency for teacher certification, but the state offers professional development for technology, learning and curriculum. Technology is viewed as a way of supporting learning in all subject areas in the state's curriculum. Annual state standardized testing in mathematics and reading is mandatory for grades 3 through 8.

New York

A 2007 review of New York's implementation of ICT in education showed that ICT is not integrated effectively and consistently state-wide. In response to this finding, New York drafted its first educational technology plan in 2010.

The New York State Education Department sets all state policy and manages all funding that comes from the federal government. In this centralized system, federal and state funding is managed at the state level, and distributed through competitive grants and funding formulas to school boards.

ICT skills are not explicitly mandated for either pre-service or in-service educators in New York and annual evaluations of teacher performance do not include a specific focus on technology. The state curriculum specifies expectations regarding students' use of ICT in each subject area.

Tennessee

Tennessee was chosen to receive the Race to the Top grant (2010) that provides funds for whole-system state reform, especially to improve assessment. Tennessee's winning grant proposal, awarding $500 million (USD), commits to improve teaching and learning in the STEM disciplines, though there is no direct mention of ICT education.

Tennessee's Department of Education sets all state policy and manages all funding that comes from the federal government. In this centralized system, federal and state funding is managed at the state level, with distribution through competitive grants and funding formulas to school boards.

Teacher candidates in Tennessee must be able to integrate technology into the classroom; however, there is no formalized ICT skills requirement for teacher certification. Technology is explicitly referenced as part of the curriculum standards for K-12 schooling, across all subject areas.

Texas
Since 1988, Texas has developed and implemented a series of wide-scale, comprehensive policy agendas with regards to ICT. Its most recent hard policy aims for pervasive use of ICT across all areas of curriculum.

The Texas Education Agency (TEA) sets all state policy and manages funding that comes from the federal government. In this centralized system, the State Board of Education implements policy, governs K-12 education, and provides funding to school districts through both competitive grants and formula funding.

Teachers' ICT skills are evaluated as part of the state-mandated teacher certification and, through the online School Technology and Readiness (STaR) system are re-assessed on an annual basis. Texas public school curriculum includes the *Technology Applications Curriculum*, which sets out standards of proficiency for each grade and across all key subject areas.

Catalonia (Spain)
In Catalonia, ICT-based education is regarded as a key component of the jurisdiction's efforts to preserve the Catalan language and culture.

The Catalan education system is hybridized, with responsibilities shared and/or divided between the state and the federal Ministry of Education. Funding for Catalonia's education system is provided by the federal government.

Catalonian educators are not tested on their ICT skills as part of teacher certification, but the state provides a number of voluntary resources and services for in-service teacher training in ICT. In Catalonia's hybridized curriculum (partially set by the federal government and partially set by the Catalan government), ICT skills are one of eight core competencies for secondary education. Catalonia's current 1 to 1 laptop program is viewed as a key means of preserving Catalan language as well as increasing parental involvement.

Victoria (Australia)
Victoria is undergoing educational reform with ICT positioned at the very center.

The federal government provides funding to states, and will soon implement a national curriculum and teacher training system, making the management of education in Australia more centralized. Education is still primarily the responsibility of states, which fund and oversee their own education systems.

Professional development opportunities are offered at the state level by Victoria's Department of Education and Early Childhood Development, as well as by the Victorian Information Technology Teachers' Association. Victoria's mandated curriculum integrates ICT across all subject areas. Standardized, national testing for literacy and numeracy occurs in grades 3, 5, 7 and 9.

Denmark

Denmark's most recent ICT program, ICT in the Folkeskole, has committed to purchasing more technology, increasing ICT education in all grades, implementing a knowledge management system and basic ICT course, and providing better teacher training and support to teachers and parents through a national network.

Denmark's Ministry of Education sets federal education policy and provides free, public schooling to the age of 16. Funding for education is both federal and municipal.

Denmark does not require ICT skills testing as part of teacher certification, however ICT professional development is offered through both municipal and federal services. Schools are mandated to write their own curricula, which are approved by municipal boards. In this framework, ICT is expected to be integrated across all subject areas.

England

Between 2007 and 2009, England initiated policy-driven, technology-enabled whole-scale system reform, aimed at granting more autonomy to schools for policy formation and funding priorities, generating more opportunities for individualized instruction (primarily through ICT), increasing parental involvement in both student learning and accountability, and increasing school safety.

Until it was renamed to the Department for Education in May 2010, the Department of Children, Schools and Families oversaw all matters related to young people in England. In this centralized system, the national government allocates funds to local authorities based on student population, need, and population density.

Teachers in England are required to undergo an ICT skills test, and the Training and Development Agency also offers ongoing professional development opportunities related to ICT integration and instruction. England's National Curriculum requires ICT-based instruction across all subject areas, and Level 3 (Grade 9) students are required to take an ICT Literacy Assessment.

Hong Kong

Hong Kong's education system is similar to Ontario's in terms of spending, curriculum implementation, and student advancement. Since 2000, Hong Kong has undertaken

policy-driven, technology-enabled whole system reform, with ICT integration into classrooms viewed as a major initiative.

The Education Bureau directs and funds education in Hong Kong, with individual schools responsible for managing their operations and planning for school development. In this centralized system, each government-aided school is provided with a formula-based Operating Expenses Block Grant, which is divided into funding for essential expenditures and funding for specific policy objectives.

Hong Kong does not require ICT skills testing as part of teacher certification, however ICT professional development is offered by the Education Bureau numerous times per year. In Hong Kong's mandated curriculum, ICT education is a key learning area for students at all levels.

Norway

Norway has formulated a nationwide policy in ICT that outlines a holistic focus on ICT in education, including a commitment to reforming teaching methods, and investing into large-scale deployment of ICT.

Norway's Ministry of Education and Research oversees the national educational policy set by the federal government. In this hybridized system, the Ministry sets a national curriculum and distributes funding to individual municipalities, which are tasked with running kindergartens, primary, and lower secondary institutions.

The Ministry of Education and Research has allocated substantial resources for professional development to teachers and school leaders. ICT skills are integrated as one of the five basic skills in the Norwegian curriculum, as well as integrated into subject areas.

Singapore

Singapore's Ministry of Education has been involved in ICT integration since 1997 when the first of three Masterplans for ICT in Education *was released. According to the* Global Competitiveness Report *(2007/2008), Singapore's education system was ranked first in terms of ability to meet the needs of a competitive economy.*

Singapore's Ministry of Education oversees all educational responsibilities in the city-state, directing the formulation and implementation of educational policies and funding all public education.

Teachers in Singapore are not required to pass an ICT skills test as part of their certification, but the Ministry of Education provides customized, in-service programs to schools and hosts educational technology conferences. Singapore's national curriculum outlines baseline standards for specific competencies and milestones related to students' ICT use, and the city-state is currently considering how to administer standardized assessments using ICT.