A CONSULTATIVE PAPER

BUILDING TOWARDS A LEARNING SOCIETY: A NATIONAL DIGITAL STRATEGY FOR SCHOOLS

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Today's world of a changing workforce, rapid advancements in technology and increased global competition mean that learning is more critical than ever. At all levels, our education system is seeing the need to change to meet the challenges of a rapidly evolving digital society. The need to have a long-term vision for education that ensures that all students experience success and have the knowledge, skills, abilities and competencies to be successful in the 21st century was never more important. Questions of how best to shape such a vision in the Irish context form the core of this discussion paper, whose purpose is to establish a discussion framework for the vision, values, principles and policy directions that are central to the dialogue around a National Digital Strategy for Schools.

The publication of the National Digital Strategy by Department of Communications, Energy and Natural Resources in July 2013 provides a foundation step towards planning what the future should be like in Ireland. The development of a National Digital Strategy for Schools is a critical part of this planning if Ireland is to realise the potential of ICT in schools and prepare our young people to live, learn and work in the 21st century. As part of the development of a digital strategy for schools, the Department of Education & Skills seeks submissions from a variety of stakeholders on the role of ICT in education. Feedback from this process along with the results of a school census carried out in 2013 will refine the articulation of policy direction and contribute to establishing a course of action that will guide how digital technologies are used in our schools for the next 5-6 years.

The purpose of this paper is to establish a discussion framework for the vision, values, principles and policy directions that are central to the dialogue around a National Digital Strategy for Schools.

Beginning the discussion

As a starting point to this conversation, we need to ask ourselves some difficult questions. Is our education system good enough to prepare students for a future none of us can predict? Will it ensure that our population has the ability to adapt, take on new roles and develop new opportunities? Do we have a long-term vision for education that ensures that all students experience success and acquire the knowledge, skills, abilities and competencies to be successful in the 21st century? What role do digital technologies play in this?

Framing the discussion

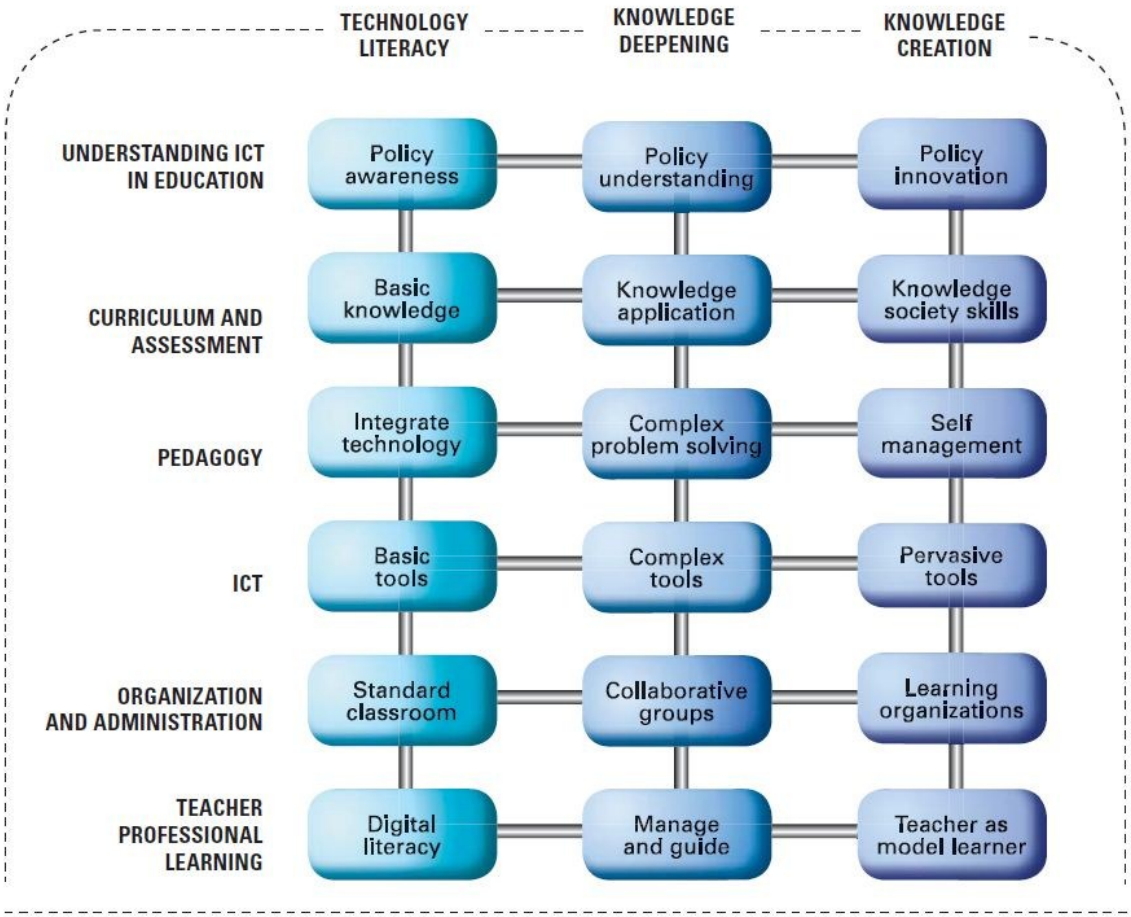
Framing a discussion that encapsulates all the aspects of teaching and learning required to interrogate these questions in the context of developments in technology is complex. The use of a framework such as that provided by UNESCO (2008, 2008a, 2011) goes some way towards meeting this need. It not only provides a way of organising the discussion but, more importantly, it provides a lens to conceptualise what being digital in learning can look like (Figure 1). Comprising six key aspects of a learning system, the framework seeks to address the implications that different policy goals and visions of ICT may have for the other components of the education system: pedagogy, teacher practice and professional development, curriculum and assessment, and school organisation

and administration. It is also useful as a means to review what has been accomplished in Ireland to date and to provide indicators of what we need to develop going forward.

The UNESCO framework identifies three complementary, somewhat overlapping approaches that connect education policy with economic and social development: *technology literacy*, *knowledge deepening* and *knowledge creation*,

- Increase the technological skills of students, citizens, and the workforce by incorporating such skills in the curriculum—or the **technology literacy** approach.
- Increase the ability of students, citizens, and the workforce to use knowledge to add value to society and the economy by applying it to solve complex, real-world problems—or the **knowledge deepening** approach.
- Increase the ability of students, citizens, and the workforce to innovate, produce new knowledge, and benefit from this new knowledge—or the **knowledge creation** approach. (UNESCO, 2008, p.8)

Figure 1: The UNESCO Framework for ICT Policies to Transform Education



It should be noted that this representation of the learning eco-system is artificially divided in order to capture many of the components involved. However, each component is just one aspect of an interrelated and interdependent ecosystem and, for change to occur, there must be movement across and between the components of the framework.

Understanding ICT in Education (Policy)

Policy for ICT use in education serves the important function of providing a rationale, a set of goals and a vision for how and why ICTs should be used in schools. Such policy is critical to motivating change and co-ordinating a series of disparate efforts so as to meet the challenges of preparing young people to live, work and learn in the 21st century. Without a shared vision to guide the national use of technology in education, ICT policy is only operational - it can become techno-centric, promoting the purchase of equipment and the organisation of teacher training without providing a strong educational purpose or goal for the use of technology (Kosma, 2008). There is also evidence to demonstrate that, in order for digital technologies to be effectively used in teaching and learning at school level, its use has to be part of the school vision and must be supported by specific national policies and strategies (Plomp et al., 2008; Shear et al., 2010a; Shear et al., 2011). This is already occuring in Ireland to a large extent. The use of digital technologies as an integral part of teaching, learning and assessment is endorsed in all recent educational policies and plans. The National Strategy to Improve Literacy and Numeracy among Children and Young People (2011-2020), (DES, 2011); Project Maths (NCCA, 2008), Key Skills Famework (NCCA, 2009) the Framework for the Junior Cycle (DES, 2011, 2012) and The School Self-Evaluation Programme (DES, 2012) all require that ICT is used as a part of student learning. In addition, the Irish Teaching Council has identified ICT as a key national priority area (The Teaching Council, 2011). The current Digital Strategy for Schools presents an oportunity to moblise how ICT can be effectively used in teaching, learning and assessment across each of these policy initiatives.

It is also recognised that policy-making has most impact when it is co-ordinated across the various stakeholders (Kosma, 2008). This is especially true when it comes to the use of ICT in education. No stakeholder can secure success and sustainability in this domain on their own. Only through collaboration within education, between education and industry, and between education and other parts of public service, can we secure success for the benefit of all learners (Hallissy et al., 2013). The consultation phase of the development of a new Digital Strategy is therefore welcomed.

ICT Infrastructure

An essential component towards the integration of ICT into schools is a robust infrastructure that provides teachers and students with relevant resources when and where they are needed. This includes resources such as computer hardware, data and networks, information resources, interoperable software and technical support.

Improving existing infrastructures continues to be a priority, even amongst those countries that have relatively advanced ICT infrastructure in place. Countries such as Australia, Canada, Estonia, Israel, Japan, Korea and New Zealand report large investment to improve current ratios (Bakia et al., 2011). In the USA, the ConnectED initiative will, within five years, connect 99 percent of America's students, through both high speed broadband and wireless within their schools and libraries.[1] Despite these infrastructural improvements, it is imperative to consider how the existing resources at teachers' disposal can be used more creatively and more effectively in teaching and learning. Increasing availability to digital tools and resources is not necessarily a precondition to knowledge deepening and/or knowledge creation. In fact, there is evidence to suggest that, at times,

[1] http://www.whitehouse.gov/sites/default/files/broadband_report_final.pdf

the emphasis on hardware can draw the focus away from potential learning opportunities; that it puts the technology above teaching (Luckin et al., 2012).

ICT infrastructure levels in schools and classrooms in Ireland are close to or exceed EU and OECD average levels. Recent EU surveys (e.g. ESSIE, 2012; 2013; Eurydice, 2011) report that Ireland ranks close to, or slightly above average across a range of indicators including student: computers ratios and Internet connectivity. However, the issue of technical support for ICTs continues to concern schools. In the 2013 ICT Census[2], on average across schools, principal teachers ranked 'insufficient level of technical support' as the second or third most serious obstacle to the use of ICTs in teaching and learning in their schools. Currently, the DES is in the process of rolling out high speed broadband (100Mbs) to all second-level schools in Ireland in an effort to open up new possibilities for teaching and learning. Findings from the 2013 ICT Census highlight that 60% of principal teachers in primary, post-primary and special schools identified access to high-speed broadband as a very high priority for their schools. To date, the initiative has focused on connecting post-primary schools to the network and there has been little discussion around the learning potentials brought by the increased levels of connectivity.

The ongoing development of ICT infrastructure in Ireland demands a concerted and co-ordinated effort across all the stakeholders in education. Questions to be addressed include:

- *What policies and action are needed at infrastructure level?*
- *How can the DES support schools to make the right decisions in terms of purchasing and installing ICT equipment?*
- *Whose responsibility is it to decide on and or supply hardware?*
- *How should technical support be provided?*
- *How can teachers be supported to explore the full potential of available digital tools and resources as tools for learning? How can they develop and share ways of using new technologies?*

Curriculum and Assessment

Pedagogies associated with the use of ICT include those that emphasise high levels of understanding of key concepts within subject areas and the ability to apply these concepts to solve complex real-world problems (Bransford, Brown, & Cocking, 2000). Most recently, curriculum development initiatives emphasise "21st century skills" (often referred to as "Key Skills" or "Key Competencies", ETA, 2010; OECD, 2005; NCCA, 2008), qualities that prepare students to live and work in a digital society. They include skills such as critical thinking and problem solving, communication, collaboration, self-regulation and information management (Binkley et al., 2012, Partnership for the 21st Century, 2003, 2005). The ability to use technology effectively and reflectively is identified as a key competence in each of these initiatives. Each initiative stresses the potential of digital technologies to transform student learning experiences by helping students become engaged thinkers, global citizens, and active learners in collaborative social learning environments.

In Ireland, the Framework for the Junior Cycle (DES, 2012) reflects the shift towards collaborative problem solving and higher-order thinking, driven by the productive use of digital

[2] A report on the 2013 ICT Census will be published by the Department of Education and Skills in Spring 2014.

technologies. It identifies as a learning statement that the student "uses technology and digital media tools to learn, communicate, work and think collaboratively and creatively in a responsible and ethical manner" (p. 6). Building on this statement, a digital element is articulated within each of the key skills embedded in Junior Cycle. These include: using digital technology to manage myself and my learning; being responsible safe and ethical in using digital technology; using digital technology to communicate; stimulating creativity using digital technology; working with others through digital technology and using digital technology to access manage and share content. Similarly, as senior cycle syllabuses are being revised, key skill elements also refer to using digital technology[3].

Assessment

Assessment reform emphasises the need for alternative and continuous assessment that is integrated into regular, ongoing instructional activity (Kosma, 2008). ICT-supported student assessment is an emerging area (Bakia et al., 2011; Binkley et al., 2012; Eurydice, 2011; EACEA/Eurydice, 2009). Until recently, the development and rollout of technology-supported assessments has been cost-prohibitive, but advances in digital technologies are now opening up new alternatives to the old modes.

As of yet, technology-supported assessment is not widely used in Europe and there is a lack of evidence on actual classroom and school use of ICT for assessment purposes (Redecker, 2013). Where used, ICT mainly supports summative assessment although interest in formative and diagnostic assessment is growing, and recent efforts have focused on assessing higher-order skills such as problem solving in collaborative settings. In a landmark paper on technology-supported assessment Binkley et al. (2012) specify in detail the components of 21st century skills, and how such skills, including complex problem solving, communication, team work, creativity and innovation, can be assessed using technology. According to Binkley et al., traditional tests tend to give relatively little attention to complex thinking and problem solving and focus on lower levels of learning, which can lead to similar emphases in classroom practice. They also argue that there is little value in simply transferring paper-and-pencil multiple-choice tests to computer-based platforms, claiming instead that computer-delivered tests should use computer tools like modelling, video data, data processing, simulation and visualisation. In support of this, they point to a range of projects that have been successful in measuring at least some 21st century skills. These include a suite of computer-based tests developed in the UK for 8-14 year olds, which are known as 'World Class Tests', and assess problem solving in mathematics, science, design and technology[4]. They also include the Virtual Assessment Performance Project, which assesses process skills by asking students to investigate authentic ecological problems[5].

Binkley et al. also argue that there is a role for large-scale assessments, to the extent that such assessments draw attention to key skills and provide a model of how they can be assessed. They cite the assessment of digital reading in PISA 2009, in which Ireland participated, as an example in that it combines a web-based reading environment with innovative assessment tasks. They argue that 21st century assessments should: be aligned with the development of important 21st century

[3] http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Senior_Cycle/Key_Skills_Framework/Key_Skills_Framework.html

[4] http://www.worldclassarena.org/en/about/aboutWCT.htm

[5] http://virtualassessment.org/index.html

goals; incorporate adaptability and unpredictability; be largely performance-based; add value for teaching and learning; make students' thinking visible; be technically sound; and generate information that can be acted upon and provide productive and usable feedback for all intended users.

In Ireland, the dialogue around ICT-supported assessment is just beginning. Questions that need to be addressed include:

- *How can digital technologies be used to assess 21st century skills? What digital tools do we need to do this? Which skills can we reasonably assess using the digital tools that are available to us?*
- *How can digital technologies be used to provide effective feedback (both formative and summative) to students on their performance?*

Pedagogy

The concept of teaching and learning through the use of ICTs is highly complex. The introduction of ICT into a learning environment does not in and of itself bring about change in pedagogical practice. Rather, its use in education is inextricably linked with understandings of the nature of knowledge and the nature of knowing. If we accept that all teaching, either explicitly or implicitly, is informed by a philosophy of teaching and learning (Becker, 2000; Bransford, Brown & Cocking, 2000; Cuban, 1993, Jones and Mercer, 1993, Becker and Riel, 1999), it follows that there is a relationship between teachers' general philosophical beliefs about teaching and learning, their pedagogical practices, and their use of ICT.

Research studies have repeatedly demonstrated that a teacher's pedagogical orientation is a dominent factor in how they use ICT in their classroom (e.g. Law et al., 2008; Plomp et al., 2009; Shear et al., 2010; Shear et al., 2010a; Shear et al., 2011). For example, a critical finding from the SITES 2006 study (Law et al., 2008) was that ICT adoption per se did not determine or change pedagogical orientation in education systems. In fact, in countries/regions such as Hong Kong and Italy, ICT-using practices exhibited a stronger traditional orientation. Research has also consistently demonstrated that computer-based interventions tend to be more effective when combined with constructivist approaches to teaching, rather than with more traditional approaches (e.g. Becker, 2000; Li & Ma, 2010; Sandholtz, et al., 1997).

In Europe, the ESSIE (European Schoolnet and University of Liege, 2013) survey reports that while most EU teachers have been familiar with ICT for teaching and learning for some years, they use it first and foremost to prepare their teaching and for teacher presentation during lessons to explain information and concepts. Few teachers use ICT to work with students during lessons and, where they do, the range of ICT use is limited. For example, approximately 35% of students at all grades across Europe never use multimedia tools as part of learning in school. In addition, between 50% and 80% of students never use digital applications such as digital textbooks, data-logging tools, podcasts, simulations and video games. The situation in Ireland is broadly similar. Reports indicate that only a minority of teachers in Ireland make considerable or extensive use of ICT in their daily teaching and learning (Conway & Brennan, 2009; Cosgrove & Marshall, 2008; DES, 2008; European Schoolnet and University of Liege, 2013). What this data suggests is that, for the most part, the use of ICT in schools is at the *technology literacy level* (UNESCO, 2008, 2008a, 2011). What this implies is

that teachers use ICT in computer laboratories or in classrooms with limited facilities to complement standard curriculum objectives, existing assessment approaches and traditional teaching methods (UNESCO, 2008).

In contrast, research has demonstrated that teachers' understanding of 21st century skill requirements have influenced the ways in which they use ICT (Plomp et al. 2009; Shear et al., 2010; Shear et al., 2010a; Shear et al., 2011). When teachers' pedagogical orientations are driven by understandings of 21st century learning, they take on a more facilitative role, provide student-centered guidance and feedback, and engage more frequently in exploratory and team-building activities with students. Referring to the UNESCO (2008, 2008a, 2011) framework, this is a *knowledge deepening approach* and implies teachers make use of ICT in ways that support an enquiry process and enable their students to work on solving complex real-world problems. The approach emphasises depth of understanding while also providing opportunities to engage in collaborative project-based learning activities that go beyond the classroom.

Finally, in *knowledge creation approach,* the curriculum goes beyond a focus on knowledge of school subjects to explicitly include the knowledge society skills / competences that are needed to create new knowledge (e.g. problem solving, communication, collaboration, experimentation, critical thinking and creative expression). The teacher's role is to design a learning community which makes pervasive use of technology to support students who are creating knowledge products and are engaged in planning and managing their own learning goals and activities. In this learning environment, a variety of networked devices, digital resources, and electronic environments are used to create and support the community in its production of knowledge and anytime, anywhere collaborative learning.

Overall, this evidence serves to strengthen the argument that the introduction or use of digital technologies does not necessarily lead to the development of innovative teaching practices. New tools can easily be used to reinforce or automate traditional methods of teaching (Campuzano et al., 2009; Law & Chow, 2008; Law, Pelgrum & Plomp, 2008; Plomp et al., 2011). Having technology in schools does not by itself lead to changes in learning outcomes (Dynarski et al., 2007) nor does it mean that educators will use it or meaningfully integrate it in teaching and learning (Cuban, Kirkpatrick and Peck, 2001; Russell et al., 2003). However, research shows that how technology is used can determine whether or not its use affects learning outcomes (Wenglinsky, 2005). This implies that emphasis needs to shift to focus on what is informing the design of the learning environment. This begs the question:

- *What needs to be put in place to enable schools to develop a culture in which teachers can move beyond technology literacy to knowledge deepening and ultimately to knowledge creation?*

Teacher Professional Learning

Teachers in today's classroom must not only be prepared to use technology but must also know how to use technology to support student learning. According to UNESCO, these have become "integral skills in every teacher's professional repertoire" (2008, p.1). How then do we go about ensuring that teachers have these skills in their repertoires?

The emphasis in many countries for quite some time has been on developing technology literacy. Professional development programmes in the area of technical skills have been more readily available than pedagogically-oriented ones (Plomp et al, 2009). There are concerns that models of professional development which focus on technical competences without pedagogical context is 'retooling' teachers for specific tasks, rather than engaging in pedagogy of a substantial nature (Watson, 2001). It is therefore not surprising to note that the two most commonly reported national priorities for teacher development programmes reported across 21 countries in the International Experience with Technology in Education (IETE) study (Bakia et al, 2011) were:

(a) supporting teachers' integration of ICTs into instruction
(b) improving teachers' pedagogical skills

Noteworthy initiatives relating to professional development are occurring in some countries worldwide whereby professional development is closely linked with other changes in the system Shear et al. (2011). For example, the ICT master plan in Singapore used the distribution of computers in schools in tandem with an extensive school based-professional development programme as a lever to change pedagogy and curriculum content. Similarly, in Jordan, the introduction of ICT to schools was connected with teacher professional development in order to develop new pedagogical models that incorporate new technologies (Kozma et al. 2010).

In Ireland, the initial focus with the launch of the NCTE in 1998 was on "upskilling" teachers with basic "ICT competencies". However, since the mid-2000s, this focus has shifted and subsequent professional development programmes have been designed with the goal of developing teachers' technological literacy and emphasise the pedagogical use of basic ICT tools in the curriculum subjects. Currently, the PDST- Technology in Education (formerly NCTE), "provides courses and other continuing professional development (CPD) opportunities to support the integration of ICT in the curriculum"[6]. The proposed changes in curriculum and assessment at both primary and post primary levels (e.g. Junior Cycle, Project Maths, Integrated primary language curriculum for infants to second class[7], review of primary maths[8], and revision of the senior cycle sciences) provide an opportunity to promote understandings of how to make innovative uses of ICTs beyond "integration".

Dialogue centring on possible uses of complex and pervasive digital technologies can take place in a meaningful context as teachers engage with these new curricula. This would enable them to develop their own thinking around how to make use of ICT in ways that would support knowledge deepening and knowledge creation approaches to learning. If, as the research suggests, the use of these new technologies implies new teacher roles, new pedagogies and new approaches to teacher education (Makrakis, 2005), perhaps a reappraisal of the design of teacher professional learning is needed. A key question which could underpin the dialogue to inform this is:

- *How can professional learning be designed so that teaching, learning, assessment and the use of ICT are inextricably linked?*

[6] http://www.ncte.ie/ICTTraining

[7] The integrated language curriculum specifications for infants to second class will be ready for consultation in early 2014.

[8] The NCCA has begun work on the structure of the revised primary maths curriculum in line with the specification for the junior cycle maths curriculum. Development of maths learning outcomes for children from infants to second class in primary schools will be informed by the work of maths researchers and experts. Background research papers are to be published in early2014.

Organisation of Learning/ Designing Learning Spaces

Changing pedagogical practices necessitates a corresponding appraisal of how learning spaces are conceptualised. This is imperative to enable the enquiry-based, collaborative nature of learning described previously. It can be enabled through the use of flexible and adaptable digitally-based resources and systems that provide high-quality learning opportunities with flexible timing and pacing through a range of learning environments. This will entail changes to the existing conceptions of timetabling and how learning is organised. It will also have implications for how teachers interact with one another and the relational roles/ responsibilities of teachers and students.

- *Is there a need to re-evaluate what students learn, when they learn, where they learn, how they learn?*
- *Should students be responsible for being actively involved in their learning?*
- *Should students collaborate and have a voice in how, where, when and the rate at which they learn, and be responsible for their choices.*
- *How can students be empowered to participate in self-reflection and evaluation throughout their education?*

To answer these questions, we need to consider how we develop an educational system that is more enabling, empowering, supportive, and less prescriptive. While this may not be an obvious immediate concern for the current Digital Strategy for Schools, it is an issue which needs to be addressed in order that schools are prepared for the long-term goal of developing a learning eco-system with a knowledge creation approach. Consequently as part of the consultative process to inform the design of the Digital Strategy for Schools the following questions need to be addressed. Do we develop a system that focuses on reducing systemic barriers to facilitate a more flexible response to the changing needs of communities and the world as well as to the diverse learning needs of students and teachers in a timely and effective way? What roles will be expected of teachers within this learning ecosystem in which they will be expected to facilitate relevant meaningful learning opportunities for students - opportunities which are experiential, multi-disciplinary and community based and which take place in a variety of settings and times, at a pace that reflects students' emerging individual needs?

In addition, how do we build a systemic approach into this learning eco-system which reflects the changing world while embracing the changing nature of technology and systematically exploring new technologies, all the time building towards a networked school-based learning community that allows for enhanced collaboration, communication, and sharing? "Connectedness" on many levels and the development of networked learning communities within and across schools and society will be essential.

Conclusion

This paper has illustrated the complexity of developing a Digital Strategy for Schools. The strategy must consider infrastructural issues but also how digital technologies are to be used in

curriculum and assessment. However while digital technologies can make things possible it is people that make things happen. It has been repeatedly stressed throughout the paper that teachers' pedagogical orientations are pivotal in how the digital technologies are used. A critical component of the Digital Strategy for Schools must therefore be how teacher professional learning is conceptualised, designed and sustained. In addition, the Digital Strategy for Schools will have far reaching implications for the ways we move towards developing learning eco-systems which are centred on Knowledge Creation rather than on Technology Literacy (UNESCO, 2008, 2008a, 2011). The ways schools are structured is ultimately a critical part of this discussion as a Knowledge Creation approach to learning cannot be supported by current conceptualisations of how school is structured.

While the UNESCO framework is useful as we seek to understand the complexities of the interplay of elements that need to be considered in order to develop a Digital Strategy for Schools, there also needs to be a robust "barometer", an adaptive mechanism, to inform decision making and support continuous improvement efforts and system change.

We need to consider what types of research can inform policy and evidence based decision making with regards to systematic innovation? Should the Department of Education and Skills participate in collaborative research projects with partners nationally and internationally? Is there a need to support action-oriented and site-based research in classrooms and schools to enable greater innovation so that the most appropriate learning environments are designed to meet the needs of the full range of learners? How can these results be shared with the education community so that policy makers can develop future policy while schools and teachers working in communities of practice can also use them to inform their practices and priorities?

As society has tried to grapple with and understand how technologies are shaping the world we live in over a very short period of time, phrases such as the "Information Society" and then the "Knowledge Society" have been coined. Of critical importance now and in the future is how people's capacities can be developed to adapt to continual change. Surely it is a time to move from descriptors to action and characterise the time we live in as "The Learning Society"? Perhaps we should concentrate our efforts on how we can build and sustain this supportive learning eco-system that enables everyone to develop the adaptive abilities which ensure engagement with lifelong learning?

As the first step towards building this Learning Society, the design of this Digital Strategy for Schools is crucial as we "need to ensure that students everywhere leave school ready to continue to learn and adapt, ready to take responsibility for their own future learning and careers, ready to innovate with and for others…open to the world and confident in their ability to shape it" (Barber et al, 2012, p.65).

To conclude, when we look at the capacity emerging technologies may offer to reorganise the institutions, practices and people of education, we need, as asserted by Daanen &Facer (2007),

> …to develop the mechanisms for an open and public debate on the nature and purpose of education in the digital age which goes beyond safe slogans such as "meeting the needs of every child" (who can disagree with that?). Instead, we need to confront the fact that longstanding assumptions about what education is for, who conducts it, and how it is assessed, may need to be challenged. (p. 28)

References

Alnoaimi, T. (2011). ICT in education policies: Jordan. In Kozma, R.B. (Ed.) Transforming Education: The Power of ICT Policies. Paris: UNESCO. Retrieved Nov 26 at http://unesdoc.unesco.org/images/0021/002118/211842e.pdf

Bakia, M., Murphy, R. Anderson, K. & Trinidad, G. (2011). *International experiences with technology in education: Final report.* U.S. Department of Education, Office of Educational Technology and the Office of Planning, Evaluation and Policy Development, Policy and Program Studies Service. Retrieved November 26 2013 at: *www2.ed.gov/about/offices/list/os/technology/iete-full-report.doc*

Barber, M., Donnelly, K., & Rizvi., S. (2012). *Oceans of Innovation: The Atlantic, the Pacific, global leadership and the future of education*. IPPR, London. Retrieved Nov 26 http://www.bath.ac.uk/education/events/documents/Barber_et_al_x2012x_oceans-of-innovation.pdf

Becker, H. (2000). The "exemplary teacher" paper -How it arose and how it changed its author's research program, *Contemporary Issues in Technology and Teacher Education* 1 (2). Retrieved November 26 at: http://www.citejournal.org/vol1/iss2/seminal/article2.htm

Becker, H & Riel, M. M. (1999), *Teacher professionalism and the emergence of constructivist-Compatible pedagogies.* Paper presented at the American Educational Researchers Association. Retrieved November 26 at: http://www.crito.uci.edu/TLC/findings/special_report2/index.htm

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., & Rumble, M. (2012). In P. Griffin, B. McGaw & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17-66). Dordrecht: Springer+Business Media.

Bransford, J., Brown, L., & Cocking, R. (2000). *How People Learn: Brain, Mind, Experience, and School:* Expanded Edition. Washington, D. C.: National Academy Press.

Campuzano, L., Dynarski, M., Agodini, R. and Rall, K. (2009) *Effectiveness of reading and mathematics software products: findings from two student cohorts*, Washington, DC: Institute of Education Sciences.

Conway, P. & Brennan, E. (2009). National policies and practices on ICT in education (pp. 383-402). In T. Plomp, N. Law & J. Pelgrum (Eds.) (2009). *Cross-national information and communication technology. Policies and practices in education.* Charlotte, North Carolina: Information Age Publishing.

Cosgrove, J., & Marshall, K. (2008). *ICT access and usage in Irish primary schools: Identifying the gaps*. Dublin, Ireland: Liffey Press.

Cuban, L (1993). *How teachers taught: Constancy and change in American classrooms.* New York: Teachers College Press.

Cuban, L., Kilpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal*, 34(4), 813-834.

Daanen, H. and K. Facer (2007), *2020 and Beyond: Educational Futures,* Futurelab, Bristol.

Department of Education and Science (DES). (2008). *ICT in Schools. Inspectorate Evaluation Studies.* Retrieved November 26 at: http://www.education.ie/en/Publications/Inspection-Reports-Publications/Evaluation-Reports-Guidelines/ICT-in-Schools-Inspectorate-Evaluation-Studies.pdf

Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., Campuzano, L., Means, B., Murphy, R., Penuel, W., Javitz, H., Emery, D. and Sussex, W. (2007). *Effectiveness of reading and mathematics software products: Findings form the first student cohort: Report to Congress*. Washington, DC: National Center for Education Evaluation and Regional Assistance.

EACEA/Eurydice (2009). Key Data on Education in Europe 2009. Retrieved November 26 at: http://eacea.ec.europa.eu/education/eurydice./documents/key_data_series/105EN.pdf

European Training Agency (2010). *Key Competences*. [Online]. Retrieved November 26 at: http://www.etf.europa.eu/web.nsf/pages/Key_competences_EN?OpenDocument

European Schoolnet and University of Liege. (2013). *Survey of schools: ICT in education. Benchmarking access, use and attitudes to technology in Europe's schools*. *Final Report* (ESSIE). Brussels: European Union. Retrieved November 26 2013 at: http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/KK-31-13-401-EN-N.pdf

Eurydice (2011). *Key data on learning and innovation through ICT at school in Europe*. Retrieved October 24 2013, from: http://eacea.ec.europa.eu/education/eurydice/documents/key_data_series/129en.pdf

Hallissy, M.; Butler, D.; Hurley, J. & Marshall, K. (2013). *Redesigning education: Meeting the challenges of the 21st century.* Retrieved November 26 2013 at: https://www.google.ie/#q=Redesigning+education%3A+Meeting+the+challenges+of+the+21st+century.

Jones and Mercer, (1993), Theories of learning and information technology. In P.Scrimhaw, (1993). *Language, Classrooms & Computers*. London: Routledge.

Kozma, R. (2008). Comparative analyses of policies for ICT in education (pp 10883-1096). In J. Voogt & G. Knezek (eds.), *International handbook of information technology in primary and secondary education.* Berlin: Springer Science.

Langworthy, M., Shear, L. and Means, B. (2010). The third lever: Innovative teaching and learning research (pp 105-122). In OECD (Ed.). *Inspired by technology, driven by pedagogy: A systematic approach to technology-based school innovations*. OECD Publishing.

Law, N., & Chow, A. (2008). Pedagogical orientation in mathematics and science and the use of ICT. In Law, N., Pelgrum, J. & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study*. Hong Kong: The Comparative Education Research Centre.

Law, N., Pelgrum, J. & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study*. Hong Kong: The Comparative Education Research Centre.

Li, Q., & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review, 22,* 215-243.

Luckin, R., Bligh, B., Manches, A., Ainsworth,S., Crook, C. & Noss, R. (2012). Decoding learning. The proof, promise and potential of digital education. Retrieved November 26 at: http://www.nesta.org.uk/publications/decoding-learning

Makrakis, V. (2005). Makrakis, V. 2005. Training teachers for new roles in the new era: experiences from the United Arab Emirates ICT programme. *Proceedings of the 3rd Pan-Hellenic Conference on Didactics of Informatics.* Korinthos, Greece.

National Council for Curriculum and Assessment (NCCA) (2008). *Key Skills Interim Report*. Dublin: NCCA.

National Council for Curriculum and Assessment (NCCA). (2008b). *Key Skills at Senior Cycle, Draft interim report*. Dublin: NCCA. Retrieved November 26 at:

http://www.ncca.ie/uploadedfiles/senior%20Cycle%20Review/keyskills.pdf

National Council for Curriculum and Assessment (NCCA) (2011). *Towards a Framework for Junior Cycle: Innovation and Identity*. Dublin: NCCA. Retrieved November 26 at: http://ncca.ie/framework/doc/NCCA-Junior-Cycle.pdf

OECD. (2005). *The Definition and Selection of Key Competencies*. Retrieved November 26 at: http://www.oecd.org/document/17/0,3343,en_2649_39263238_2669073_1_1_1_1,00.html

Partnership for 21st Century Skills. (2007). *The Intellectual and Policy Foundations of the 21st Century Skills Framework*. Retrieved November 26 at: http://youngspirit.org/docs/21stcentury.pdf.

Partnership for 21st Century Skills. (2008). *21st Century Skills, Education and Competitiveness: A Resource and Policy Guide*. Washington, DC: Partnership for 21st Skills. Retrieved November 26 at: http://www.p21.org/storage/documents/21st_century_skills_education_and_competitiveness_guide.pdf

Plomp, T., Law, N. & Pelgrum, J. (Eds.) (2009). *Cross-national information and communication technology. Policies and practices in education.* Charlotte, North Carolina: Information Age Publishing.

Redecker, C. (2013). The use of ICT for the assessment of key competences. European Union, Luxembourg: Publications Office of the European Union. Retrieved November 26 at: http://ftp.jrc.es/EURdoc/JRC76971.pdf

Russell, M. et al. (2003), "Examining teacher technology use: implications for pre-service and in-service teacher preparation". *Journal of Teacher Education*, Vol. 54 (4), 297-310.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: TeachersCollege Press.

Shear, L., Gorges, T., Means, B., Singleton, C., Novais, G., Gallagher, L., & Lundh, P. (2010).The Microsoft Innovative Schools Program Year 2 evaluation report. Redmond, WA: Microsoft. Retrieved November 26 at: http://www.microsoft.com/en-us/download/details.aspx?id=9791

Shear, L., Novais, G., & Moorthy, S. (2010a). *ITL Research: Pilot year findings and lessons learned*. Redmond, WA: Microsoft.

Shear, L., Gallagher, L., & Patel, D. (2011). *ITL Research 2011 findings: Evolving educational ecosystems.* Redmond, WA: Microsoft.

UNESCO (2008). *ICT competency standards for teachers: Competency standards modules.* Paris: UNESCO. Retrieved November 26 at: http://unesdoc.unesco.org/images/0015/001562/156207e.pdf.

UNESCO (2008a). *ICT competency standards for teachers: Policy framework.* Paris: UNESCO. Retrieved November 26 at: http://unesdoc.unesco.org/images/0015/001562/156210E.pdf.

UNESCO (2011). *ICT competency standards for teachers: Policy framework. Paris: UNESCO. .* Retrieved November 26 at: http://iite.unesco.org/pics/publications/en/files/3214694.pdf

Wenglinsky, H. (2005), *Using technology wisely: The keys to success in schools*. New York: Teachers College Press.