Microsoft

Redesigning Education: Meeting the Challenges of the 21st Century

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"Education is the most powerful weapon which you can use to change the world. "

Nelson Mandela

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Foreword

We in Microsoft Ireland are delighted to launch *Redesigning Education: meeting the challenges of the 21st Century*. A dynamic education system is a fundamental ingredient of a vibrant, innovative and just society. Today, more than ever, the pace of change is breathtaking, relentless, and potentially liberating for all humanity. The days of adopting 'a wait and see' attitude toward change are over; the scale of change in our society over the past five years attests to this fact.

Moreover, economic competition, the ability to foster innovation and more importantly support an entrepreneurial culture within countries are seen as key drivers of any education system. It is widely acknowledged that the stakes are high yet we, as citizens, must embrace these challenges and ultimately redesign our education systems to better meet them.

In this document, we have outlined some of the key arguments as to why this change is necessary, what other countries are doing and we have provided some examples of noteworthy practice. We are advocating that the education community use this document to reflect on the challenges they are facing in remodelling their schools and classrooms.

Finally, I would like to thank Dr Deirdre Butler from St Patrick's College Drumcondra and Michael Hallissy and John Hurley from H2 Learning and the Microsoft Education Team for working on this paper and having the foresight to engage in this work.

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Executive Summary

There is now growing evidence that the 21st century workplace is an ever-evolving environment where employers expect their workers to possess a wide range of skills and competences for this global competitive environment. The core set of skills (c.f. Appendix 1) expected include being knowledgeable about the world, thinking outside the box, being smarter about sourcing information, having good people skills, an ability to solve problems, to work as part of a team and ultimately to become a lifelong learner.

Countries, like Ireland, are now competing for jobs on an international stage and there is a need for us to differentiate ourselves from other countries, particularly emerging economies where labour costs are significantly lower. The industrial model of education, which placed a heavy emphasis on the transmission of knowledge from teacher to student and was primarily assessed by summative examinations, is widely accepted as being no longer appropriate. Therefore many countries are now redesigning their education systems to meet the demands of this changing world.

It is now recognised that we in Ireland also need to implement significant reform in our education system so that it remains relevant to the changing needs of Irish society. The lessons learnt from countries, such as Finland and South Korea, that have successfully transformed their education systems can help us in shaping a new experience for teachers and learners.

We live in an increasingly connected world where the role of technology is impacting on the type of work in which individuals engage. There is greater movement of workers between nations and today our young people are competing in a global economy. Technology is also flattening company structures and there is a need for employees to possess the new 21st century skill-sets in order to work in these organisations. Many of these companies expect their employees to engage in lifelong learning, much of which will be self-directed and facilitated by digital technology. This world is very different from previous generations when companies were typically more hierarchical.

These changes in the workplace and in society at large have implications for schools. There is now a growing need for school systems globally to re-imagine how they organise teaching, learning and assessment so as to better meet the needs of society in the 21st century. Numerous governments, including Australia, Finland, South Korea and Singapore, have already begun to implement fundamental changes to their education systems. All have recognised the key role that ICT can play in transforming teaching, learning and assessment. These countries have continually invested heavily in ICT over many years yet they acknowledge that hardware investment alone is not sufficient. There needs to be a fundamental rethink on how we design teaching, learning and assessment to meet the challenges and opportunities that our young people will face today and in the future. This

is an exciting challenge and one that is being informed by research and by the needs of society.

Consequently all these countries are now in the process of moving away from an over-reliance on teachers preparing students for high-stakes summative assessments to a fundamentally different model of education that is more focused on cultivating engaged connected global citizens who are life-long learners. Young people today expect to be actively engaged in their learning, rather than being passive recipients of teacher-transmitted information. Technology, particularly the Internet, has contributed to an 'information explosion', accessible anytime, anyplace. Within such a context there is a need for educators to consider how we can support our young people to become critical thinkers and to take responsibility for their own learning. This is the challenge that many countries, including Ireland, face today and is a central theme of this paper.

Ireland is now embarking on a significant project to transform our education system, particularly at second-level. Initiatives, such as Project Maths, and recent plans to transform the Junior Certificate programme are to be welcomed and have been informed by best practice in the field of education transformation. In particular the plans to reform the Junior Certificate programme and to transform teaching and assessment strategies for the new programme have the potential to deliver fundamental change in Irish schools. The move away from teacher-led pedagogies and an over-reliance on summative high-stakes examinations fits with best international practice and is to be welcomed and supported.

In addition, the proposal to introduce short courses at Junior Cycle level is also a welcome development. We have seen that countries, such as Singapore, South Korea and Finland, have already reduced the amount of curriculum content that schools are expected *'to cover'* thus placing a greater emphasis on teaching and learning for understanding. Such a paradigm shift has been aptly labelled in Singapore as *'teach less, learn more'*. The evidence from international assessments, such as PISA and TIMMS, demonstrates that the countries that have shifted from a traditional transmission model of teaching to one that is more student-centred are now performing significantly better on these measures.

It appears that there is now political support to embark on transforming our education system in Ireland, as evidenced by the current Programme for Government and by recent announcements on the reform of the Junior Certificate. Yet the challenge for Irish society is to firstly consider what type of education system we want for our children and then to ensure it is implemented. However this conversation needs to involve all of society not just politicians, government agencies and departments, and teachers. It needs a strong input from industry, parents, young people, and others who have a stake in this discussion.

These conversations should examine the needs of our society and the ways in which our entire education system, from Junior Infants right through to university level, can be transformed so that we regain our international competitiveness. Undoubtedly much innovation has occurred in the system already but it is now time to create a vision for a

smarter education system that better meets the needs of a modern 21st century society.

Such a vision should consider the role of digital technologies as a central component and not as an add-on, as has often been the case in the past. Digital technologies have the potential to transform how teachers teach and students learn. Recent developments, in fields such as mobile computing, online learning and the expansion of broadband services, are providing new opportunities for innovation across our education system. However, the creation and adoption of new technologies is not enough, there is now an urgent need to support teachers to design and implement engaging learning activities for their learners.

"The world is changing and as Tom Friedman has demonstrated, it is increasingly flat. Globalization is changing everything about how we work, how we communicate and ultimately how we live.

(Darling-Hammond, 2010, p. 3)

Introduction

The world is changing and as Tom Friedman has demonstrated, it is increasingly flat. Globalization is changing everything about how we work, how we communicate and ultimately how we live.

(Darling-Hammond, 2010, p. 3)

In the second decade of the 21st century, as our world becomes more complex and interconnected, there is considerable discussion taking place in relation to what and how our schools are teaching our young people (ETS, 2002; NCREL/Metiri, 2003; Partnership for 21st Century Skills, 2008; Wallis, 2006).

There is a growing body of evidence that students will require a different set of capabilities to live and work effectively in the 21st century, (often referred to as 21st century skills, c.f. Appendix 1 for a fuller explanation), which in turn implies a transformation of our education systems (Dede, 2007; Kozma, 2005). As the Hong Kong Commission for Education indicates:

The 21st century is characterised by the availability of abundant information, advanced technology, a rapidly changing society, greater convenience in daily lives, and keener international competition. In response to these changes, our Education Reform should aim at nurturing in the new generation characteristics and abilities capable of meeting the challenges of the new century.

(Education Commission Hong Kong, 2003, p. 4)

Transforming existing education systems is a global challenge and one that many countries are currently engaged with in an effort to remain competitive. Nations are acutely aware that:

The best employers the world over will be looking for the most competent, most creative, and most innovative people on the face of the earth... Beyond [strong skills in English, mathematics, technology and science], candidates will have to be comfortable with ideas and abstractions, good at both analysis and synthesis, creative and innovative, self-disciplined and well organised, able to learn very quickly and work well as a member of a team and have the flexibility to adapt quickly to frequent changes in the labour market as the shifts in the economy become ever faster and more dramatic.

(National Center on Education and the Economy, 2007, p. XXV)

President Obama, when speaking on the issue of education in March 2009 (Associated Press, 2009), stressed the need to overhaul the American education system as an economic imperative that could not wait. The Australian government has already taken action to implement a 14.7 billion dollar investment programme (Australian Government, 2009) that

"will provide infrastructure funding so each of Australia's 9,540 schools can meet the needs of 21st century students and teachers". The Australian government views this investment as a key component of its economic stimulus package.

Singapore is also striving to develop "a nation of thinking and committed citizens capable of meeting the challenges of the future, and an education system geared to the needs of the 21st century" (Goh, 1997). Implementing this transformation has involved significant investment in ICT and this is considered an integral part of the country's economic development.

> *Schools are knowledge organisations... They must therefore serve as catalysts for learning and discovery and the wellsprings of the knowledge society.*
>
> *(Hean , October 23 2001)*

Singapore launched the first phase of its ICT plan in 1997, at the same time as many nations were grappling with the issue of investing in technological infrastructure and integrating ICT into their education systems. Today, its ICT plan is no longer solely focussed on technology but on how digital technologies can assist in transforming the existing education system to better meet the needs of a 21st century global economy. Consequently, with the launch of the third phase of the ICT plan for schools in 2008, rather than being 'technocentric' the focus is on transforming the education system.

Dr Ng Eng Hen, Minister for Education and Second Minister for Defence stated at the launch event that, "We want greater engagement of students to encourage more self-directed questioning and learning" (Ng, 2008a). Singapore's master plan has four goals: to strengthen competencies for self-directed learning; to tailor learning experiences according to the way that each student learns best; to encourage students to go deeper and advance their learning, and to enable students to learn anywhere. These goals are very strongly aligned with the vision of education as outlined by groups such as the OECD (2005a), the EU (2008a) and the Partnership for 21st Century Skills (2007).

In the Republic of Ireland, discussion around the need to transform our education system to better meet the challenges facing us in this new century is on the increase. Reports such as, the *Next Leap* (Ryan, 2009) and **Building Ireland's Smart Economy** (Government of Ireland, 2008), have called for the "transformation of education" in Ireland. In particular such documents stress the need to foster entrepreneurship and to promote STEM subjects (Science, Technology, Engineering and Maths) in our schools now and in the future.

The National Competitiveness Council (NCC, 2009) has also called for the improvement of STEM skill levels as well as a transformation of how these subjects are taught in schools. Towards this end, while acknowledging the harsh financial situation at present, the NCC recommends a continuation of investment in science

labs, ICT infrastructure and on-going teacher professional development in our nation's schools. The National Council for Curriculum and Assessment (NCCA) has strongly endorsed 21st century approaches to teaching and learning through initiatives such as Key Skills and Project Maths. Though these innovative

programmes are welcome, there is a need for educators, business leaders, politicians and society at large to engage in debate and consider how the education system in Ireland should be structured to best meet the needs of a 21st century knowledge society. Various governments have outlined their views in relation to creating a Smart Economy (Government of Ireland, 2008; Government of Ireland, 2010; Government of Ireland 2011); these are to be welcomed and are certainly key documents in any future debate. We suggest there is also a need to consider what a smart education system might look like as part of an overall vision for Ireland's Smart Economy.

The change agenda has accelerated of late with Minister for Education and Skills, Mr Ruairí Quinn, launching a significant programme to reform the existing Junior Cycle (NCCA, 2011b). The Minister launched the NCCA Reform Proposals on November 3rd 2011. These proposals address two central issues – the problem of rote learning and curriculum overload. Minister Quinn has also stressed that there needs to be a greater emphasis on the role of ICT in teaching, learning and assessment in the reformed Junior Cycle. The Chief Executive of the NCCA, Dr Anne Looney, noted that implementing change in the Irish education system has been traditionally slow but there is now an imperative to act more quickly. She called on schools to embrace this change agenda and to transfer the plans "from the paper and from the screen into the learning and lives of students" (NCCA, November 2011b). In addition the Minister has recently announced plans to "shake up the CAO System" in an effort to improve the quality of teaching and learning at Leaving Certificate Level and to reduce the stress on students. It is planned to introduce these changes for students sitting the Leaving Cert in 2016 and they are to be welcomed (Irish Independent, 2013).

The Minister and the NCCA have advanced these ideas further in recent months and published their Junior Cycle Framework in October 2012 (Quinn, 2012). There are numerous innovative proposals in these plans that are ultimately designed to improve the experience of young people in second-level schools. The next challenge will be to implement these changes throughout the education system over the next five years and the Minister proposes to begin this work during 2013/14. The Framework provides greater opportunities for schools to develop their own courses and to take a much more active role in the assessment of their students' learning. Such developments fit with international best practice and are to be welcomed.

Thus there is evidence that a number of countries are actively transforming their education systems to better meet the demands of a global 21st century society. Reforms have reduced the amount of content students and teachers have to engage with to equip learners with the skills and competences required in society today.

Interestingly, these countries have also focused on the role ICT can play in transforming their education systems. Initially they concentrated on providing ICT infrastructure but they have moved beyond this to focus on how they can reinvent teaching, learning and assessment using these digital tools. They have successfully embedded ICT into their reform programmes so that the emphasis is now on transforming teaching, learning and assessment and less on technological infrastructure. There is a need to initiate such a discussion in many countries around the globe so that society can transform its existing education systems to better meet the demands of the 21st century.

To help inform such a debate, this paper will begin by examining the following questions:

- Do children learn differently today?

- How is the workplace changing in the 21st century?

- What are the key capabilities employers look for in today's graduates?

Having explored these questions we then share some exemplary '21st century learning environments', before concluding with a call to action, so that this issue is debated intensely across all sectors of society. This paper is intended to provoke discussion around the issues raised so that we can begin to have an informed debate about what our education system could look like in order to meet the demands of the 21st century.

Do children learn differently today?

Don Tapscott's book, *Grown up Digital* (2008), has a chapter entitled *The Net Generation as Learners*. He begins by referencing a 2007 YouTube video, *A Vision of Students Today* (Wesch, 2007), created by Kansas State University cultural anthropologist Michael Wesch and two hundred of his students. These third-level students outline how today's education system is not meeting their needs particularly the 'one size fits all' curriculum with all students reproducing the same content in an examination. Similar criticisms are emerging in relation to primary and post-primary education (K-12), where teachers are under enormous pressure to cover large amounts of content that will be tested, often superficially, using standardised tests.

> *Because of the accountability systems built into this model of educational reform [NCLB], teachers are using weak but rapid instructional methods, such as lecture and drill-and-practice, to race through the glut of recipes, facts, and test-taking skills they are expected to cover.*

> *(Dede, 2007, p. 17)*

Dede also notes that research evidence demonstrates that "guided inquiry, collaborative learning, mentoring, and apprenticeships are far more effective pedagogical strategies" (2007, p. 17). However, the lecture approach still persists across all education sectors. This paradigm is further reinforced by the summative assessment system, the "drive-by" tests (Dede, 2007, p. 18), where there is no diagnostic or just-in-time feedback for teachers.

In Ireland there has also been criticism of our current state examinations, the Junior and Leaving Certificate examinations. The Leaving Certificate in particular has been criticised as a high-stakes summative assessment (Hyland, 2011) which has led to a narrowing of student learning experiences. The former Minister for Education and Science, Mr Batt O' Keeffe, stated that the Junior Certificate was "driven by rote learning and examination pressures, rather than the promotion of real understanding and skills" (Flynn, 2009). Now there are welcome moves to revamp these assessments to better reflect the needs of our learners in today's society.

The NCCA is currently considering modes of assessment that better meet the needs of students and society at large. The Innovation and Identity initiative (NCCA, 2010), for example, is engaged in rethinking the Junior Cycle educational experience. An important element of this process is the future of the Junior Certificate exam. Others, such as Tom Boland, Chief Executive of the Higher Education Authority, have also called for an 'overhaul' of the Leaving Certificate as too many students put all their energy into exam success and "less into understanding, analysing, and

communicating what the curriculum presents" (Flynn, 2010). However these criticisms of the Leaving Certificate had previously been highlighted by the NCCA as early as 2002 in its documentation *Developing Senior Cycle* (NCCA, 2002a & 2002b).

It appears that on this occasion action will be taken to implement real changes at Junior Cycle level. Professor Tom Collins, former chairperson of the NCCA, noted that this is the third time attempts have been made to reform this phase of education. He believes that on this occasion change will occur as there is strong alignment between a number of key factors (NCCA, 2011b).

The launch of the Junior Cycle Framework (Quinn, 2012) is the latest chapter in reforming the state examination system. The Minister has stated that the reformed Junior Certificate will no longer be 'a high-stakes exam' and that the NCCA and the SEC are considering new modes for assessment, such as e-portfolios, that better meet the needs of today's students (Marshall, 2012). The Minister and the NCCA have shown strong leadership in bringing forward these changes and their implementation will undoubtedly require support from many sectors of society including teachers, unions, parents, industry and students. These are welcome changes and it will be important to support schools to implement them effectively over the coming years.

It is evident that there needs to be an urgent rethinking of how students are to be assessed. When considering this issue the characteristics of today's generation of students need to be considered. Many of the 'Net Geners', those born between January 1977 and December 1997, are not content to sit back and passively listen in school, they want to be more actively involved in their learning.

They want a choice in their education, in terms of what they learn, when they learn it, where, and how. They want their education to be relevant to the real world, the one they live in. They want it to be interesting, even fun.

(Tapscott, 2008, p. 126)

Young people today want a more personalised learning experience where they are active participants and collaborators with their peers and their teachers. In today's global society learning also needs to be viewed as a lifelong process, not something that we only engage in during the early stages of life (Hagel III et al., 2010). The U.S. Department of Labor estimates that many of today's workers will hold more than 10 jobs before they reach the age of 40 and to be competitive they will need to engage in lifelong learning (Card & Dinardo in Dede, 2007). This ability to continue to learn throughout one's lifetime is even more imperative when one considers that the top 10 in-demand jobs projected for 2010 did not exist in 2004 (Gunderson, Jones & Scanland 2004; Hagel III et al., 2010).

" They want a choice in their education, in terms of what they learn, when they learn it, where, and how. They want their education to be relevant to the real world, the one they live in. They want it to be interesting, even fun. "

(Tapscott, 2008, p. 126)

However, changing education systems to meet the needs of these Net Geners will not be easy, particularly where there is strong emphasis on exam performance. We must acknowledge the challenges systems and schools face in changing their existing structures and we must identify barriers which can include:

- the challenge of changing mind-sets particularly with regards to 'covering' the curriculum;

- allocation of time in schools;

- the issue of assessment.

Nevertheless we need to face these challenges and consider what the economic and social consequences of not addressing them might be. The increase in job losses since 2008 (Forfás, 2009), particularly in the manufacturing and construction sector, should be a call to action for Ireland. Faced with rising global unemployment, we urgently need to question the relevance of our current education system and ask do we have a smart education system equipped to meet the challenges of the 21st century?

The 21st Century Workplace – What is different?

The world is a very different place today as we grapple with the worst global economic recession since the Great Depression (Keenan, 2009; US Congress, 2011). Globally countries are focusing on how they can restructure their economies in order to be ready for the up-turn that will inevitably come.

Successive Irish governments have reacted to this global crisis by publishing their own strategies to realign the Irish economy. Initially, the Fianna Fáil/Green Party coalition published *Building Ireland's Smart Economy* (Government of Ireland, 2008) and this has been followed more recently by the Fine Gael/Labour coalition *Jobs Initiative Strategy* (Department of Finance, 2011). Both of these documents highlight the role education and training will play in returning the Irish economy to growth. This sentiment is also echoed in numerous recent reports (Government of Ireland, 2008; Ryan 2009; NCC, 2009 and Government of Ireland, 2012) that have reiterated the need for Ireland to continue to invest in and to re-invent our education system to meet the needs of our citizens in the 21st century.
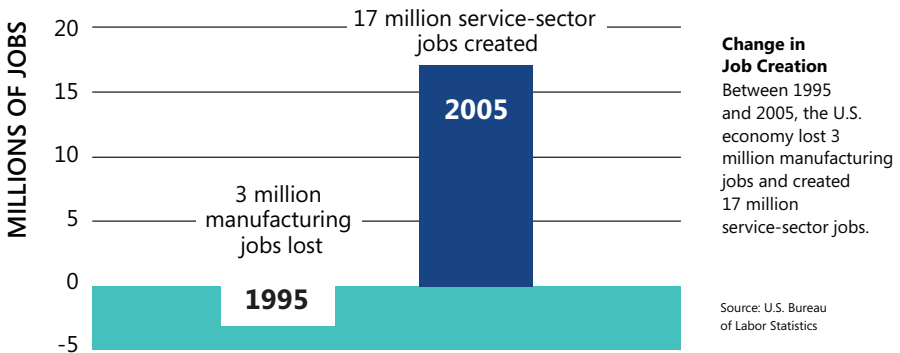
However, there is significant evidence, particularly in the Western world, that the concept of work is changing with a move away from traditional manufacturing to service type jobs. Indeed, "technological automation has already replaced *doing* tasks and is now beginning to replace tasks in which information can be broken down and digitally translated and outsourced" (Mishra & Kereluik, 2011, p. 3303). Consequently, the demand now and in the future is for non-routine skills such as expert thinking and complex communication.
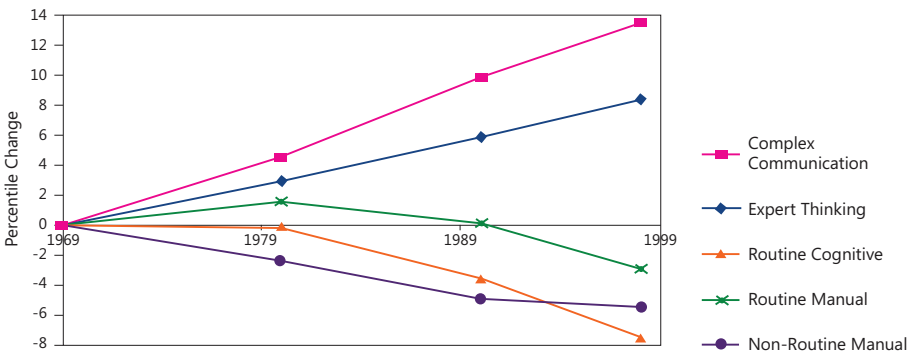
(Levy and Murnane, 2005, p. 15)

It is generally understood that countries which "do not develop workers with the skills and capacities to meet new labour market dynamics risk falling behind" (Wagner, 2008 in Langworthy et al., 2010, p. 106). This risk has been recognised for some time. For example, research from the UCLA Anderson School of Management (Karmarkar & Apte, 2007; Apte, Karmarkar & Nath, in Partnership for 21st Century Skills, 2008) found that in 1967 the production of material goods (such as cars, chemicals and industrial equipment) and the delivery of material services (such as transportation, construction and retailing) accounted for nearly 54% of U.S. economic output. In stark contrast, by 1997 the production of information products (such as computers, books, televisions and software) and the provision of information services (such as telecommunications, financial and broadcast services and education) accounted for 63% of U.S. output. During the same thirty-year period, information services increased by 20%, growing from 36% to 56% of total U.S. economic output.

10-Year Job Trends Underscore Shift to Service Sector

Change in Job Creation Between 1995 and 2005, the U.S. economy lost 3 million manufacturing jobs and created 17 million service-sector jobs.

Source: U.S. Bureau of Labor Statistics

(Partnership for 21st Century Skills, 2008, p. 3)

The U.S. Bureau of Labor Statistics found that 3 million manufacturing jobs were lost between 1995 and 2005, while during the same period 17 million service-sector jobs were created. More recently it has been stated that "at least 70% of U.S. jobs now require specialised knowledge and skills, as compared to only 5% at the dawn of the last century" (Darling-Hammond, 2010, p. 2). These new skills include the capacity to:

• Design, evaluate and manage one's own work so that it continually improves;

• Frame, investigate and solve problems using a wide range of tools and resources;

• Collaborate strategically with others;

- Communicate effectively in many forms;

- Find, analyse and use information for many purposes;

- Develop new products and ideas.

(Wagner, 1998 as cited in Darling-Hammond, 2010, p. 2)

Ireland too has witnessed major job losses in our manufacturing sector in recent years (Forfás, 2009; Keenan, 2009) and this trend is expected to continue with the relocation of many Irish manufacturing jobs to locations with lower wage costs. The Forfás Expert Skills Group for example, forecast in 2007 that "the service sector will increase in relative importance, while 'traditional' manufacturing and agriculture will decline" (Forfás, 2007, p. 34). Forfás also forecast that the greatest increases in employment would occur in the 'professional', 'associate professional' and 'personal and service' groupings. This trend has continued in recent years with a decline in the number of full-time workers in the industrial sector and an increase in those working in the services sector (Forfás, 2011). Though all sectors have experienced job losses in the past three years Forfás indicate that the services sector has rebound in recent years in comparison to the industrial sector. It reported that this was particularly true in the IT consultancy field. This is a global challenge that we in Ireland correspondingly face as we try to move our economy away from an over-reliance on manufacturing to new jobs in the service sector.

Coupled with these changing employment sector trends western economies are also struggling to be competitive in the traditional manufacturing and agriculture sectors as developing economies have an advantage in terms of their low wage structures.

Because other nations have, and probably will continue to have, the competitive advantage of a low wage structure, the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring.

(Committee on Prospering in the Global Economy of the 21st Century in Partnership for 21st Century Skills, 2008, p. 4)

The changing demands of a more complex, interconnected global society and the inability to compete against low-wage economies are real challenges that demand a rethinking of existing systems and structures.

Company Restructuring

In such challenging economic times, companies tend to change their behaviour and move to flatten management structures, decentralise decision-making, share information, use task teams and introduce more flexible work arrangements in order to increase their productivity and innovation (Black & Lynch, 2003 in Partnership for 21st Century Skills, 2008). Rolls Royce is an example of a company which introduced a new communications strategy in 2006 that yielded impressive gains for the company. Prior to introducing the changes Rolls Royce's communications strategy was very top-down, with all communications emanating from a centralised office. The new communications system allowed front-line workers to communicate cost-saving approaches directly to their managers quickly and in a structured way. Since its introduction the company has realised significant gains in areas such as operating income, reduced labour hours and reduced errors, while also seeing an increase in knowledge among workers and customers (Dulye, 2008).

Another successful example of a company that has introduced a 'flat structure' is Best Buy in the United States. Brad Anderson, the CEO of Best Buy, believes that the job of management today is not to supervise or manage in the old sense but to "create the context whereby the [employees] can be successful" (Tapscott, 2008, p. 178). Many companies are now realising they need to change their old structures to better reflect the needs of their employees so that they become more successful organisations.

Nation Restructuring

Not only companies, but entire nations, are facing up to the challenges of surviving and competing in a new global economy and the case of Finland is of particular interest. Starting in the 1980s, Finland dismantled its rigid student tracking system and eliminated the state-mandated testing system that was used for this purpose. Then in the early 1990s, when Finland was in an economic recession (with an average GDP growth rate of -3.68%), in an attempt to transform the country's economic fortunes, the Finnish government enacted a series of fundamental structural changes, particularly in relation to its education system (Kozma, 2005). Its strategy focused on teacher development coupled with a curriculum and assessment system that focused on problem solving, creativity, independent learning and student reflection (Finnish National Board of Education, 2007). Consequently Finland:

- provided access to high quality education across the country;

- recruited high quality teachers with a degree of autonomy;

- developed student-oriented assessment that gives students feedback on their progress;

- developed an approach to education that treats students as autonomous learners who are guided to develop their study skills and plan their life career.

(Kozma, 2005, p. 7)

The focus of the 1990s curriculum reforms on science, technology and innovation, led to an emphasis on teaching students how to think creatively and manage their own learning. The Finnish Government invested heavily in ICT to improve the quality of the education system, so that by increasing students' understanding of science and mathematics they could "support a more productive, technology-based economy" (Kozma, 2005, p. 3). As Sahlberg (2009, p. 20) noted:

> *the rapid emergence of innovation-driven businesses in the mid-1990s introduced creative problem-solving and innovative cross-curricular projects and teaching methods to schools. Some leading Finnish companies, such as Nokia, reminded education policy-makers of the importance of keeping teaching and learning creative and open to new ideas, rather than fixing them to predetermined standards and accountability through national testing.*

The investments made by the Finnish Government in technological infrastructure, education, research and development placed a strong emphasis on the creation and sharing of new knowledge. As a result, a "typical feature of teaching and learning in Finland is encouraging teachers and students to try new ideas and methods, learn about and through innovations and cultivate creativity in schools…" (Sahlberg, 2007, p. 152 in Darling Hammond, 2010; p. 170). These changes have propelled Finland to the top of the international assessment rankings, as indicated in the OECD Programme for International Student Assessment (PISA) results, and have successfully closed what was once a large intractable achievement gap (ibid, 2010). The PISA assessments require more advanced analysis and knowledge, they go beyond 'did students learn specific facts?' to ask, 'what can students do with what they have learned?' (i.e. the students' ability to apply what they know to new problems).

Finland was not alone in initiating reform during the 1990s. Singapore also shifted its economic development plan towards a knowledge-based economy and broader-based economic participation. It too took a more holistic approach within education and the plan strengthened the connections between school, home and community, "as part of a larger social development plan that encouraged a more active participation of citizens in community life and economic innovation" (Kozma, 2005, p. 4).

> *Innovation is no longer simply encouraged; it has to become an imperative of all professional endeavour in business, government and education …. A new mindset and new strategies are needed to foster innovation, all organisations, especially schools, will have to respond to the imperatives of innovation at work around us.*
>
> *(Hean, 2001)*

The Ministry of Education in Singapore consequently instituted reforms to improve the quality of the education system and to "support students' development of critical thinking, creativity and enterprise" (Kozma, 2005, p. 4). These reforms have borne fruit as Darling-Hammond recently states that a "spirit of creativity and innovation is visible throughout the

schools, which are encouraged to engage both students and teachers in experiential and cooperative learning, action research , scientific investigations, entrepreneurial activities and discussion and debate" (Darling-Hammond, 2010, p. 6).

Another example of a nation responding effectively to change is South Korea which in the space of one generation ranks third in college-educated adults, with the majority of its young people completing post-secondary education (OECD, 2005b) when previously less than a quarter of its citizens had successfully completed high school. In comparison to South Korea where over 60% of adults have a degree, only "about 35% of an age cohort in the United States gains a college degree, as compared to about 50% in European countries..." (Darling-Hammond, 2010, p. 16). The OECD (2005 in Darling-Hammond, 2010, p. 16) found that for every year the average schooling level of a population is raised, "there is a corresponding increase of 3.7% in long-term economic growth".

Kozma (2005) observes that both the Finnish and the Singaporean examples place a premium on quality education rather than the duration factor (i.e. how long students attend school). It is interesting to note that:

the more equitable investments made by high-achieving nations are also more steady and more focused on critical elements of the system: the quality of teachers and teaching, the development of curriculum and assessments that encourage ambitious learning by both students and teachers, and the design of schools as learning organisations that support continuous reflection and improvement.

(Darling-Hammond, 2010, p. 8)

There is now a:

growing consensus on the need to dramatically rethink how learning happens inside and outside schools. Much of this debate is centred on the potential for technology to play a more direct and central role in student-centred learning.

(Mitra et al., 2005; Christensen et al., 2008, as cited in Langworthy et al., 2010, p. 106)

Consequently, we need to create an education system that is mindful of the complexities and challenges of the change process and aware of the need to empower those working on the challenges to create multiple customised solutions, rather than being preoccupied with finding the definitive 'solution' centrally and disseminating it locally for 'implementation'. Proactively reforming our education systems in this way would be a significant step towards meeting the global challenges we face. Before we engage in a restructuring of our education systems to support economic growth we must first examine systematically what skills and competencies the 21st century global citizen will require.

"In an economy driven by **knowledge** rather than manufacturing, employers are already valuing very different skills, such as **creativity, communication, presentation skills and team-building**. Schools are at the front line of this change and need to think about how they can prepare young people for the future workplace."

(Green & Hannon, 2007, p. 15)

21st Century Workers
– What skills will they need?

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There is now a growing list of skills employers are expecting of their employees, reflecting the changing world of work outlined in the previous section. A *Time* magazine article (Wallis, 2006) identified four skills as being essential in the 21st century and we elaborate on these below. Others, such as the European Parliament and the Council of the European Union (European Commission, 2008b), the International Society for Technology in Education (2007), the Metiri Group (2003), the OECD (2005a), and the Partnership for 21st Century Skills (2007), have also identified a range of 21st century skills and we have attempted to map the skills in the *Time* magazine article to these sources.

1. **Knowing more about the world:** The *Time* article quotes Mike Eskew, CEO of UPS, who spoke about the need for workers who are "global trade literate, sensitive to foreign cultures, conversant in different languages" (Wallis, 2006). The Partnership for 21st Century Skills (P21) has labelled this skill as *Global or connected citizenship*. While the EU refers to this as *Communication in Foreign Languages* and *Cultural awareness and expression*. Such skills are essential for social and economic development in our "flat world" (Friedman, 2005) when one considers the increased cultural diversity due to globalisation. Coupled with this is the development of ethical awareness which is crucial for success in a culturally diverse society. It involves "the ability to imagine oneself in someone else's position and feel *with* that individual…because success in social and economic realms necessitates a deep understanding of human emotions and successful human interactions" (Mishra & Kereluik, 2011, p. 3310). The EU refers to this as *Initiative* and *Constructive Management of Feelings*.

2. **Thinking outside the box:** Marc Tucker, president of the Washington-based National Centre on Education and the Economy, stated that the jobs that are not outsourced or automated will "put an enormous premium on creative and innovative skills, seeing patterns where other people see only chaos" (Wallis, 2006). "Creativity and innovation include the ability to evaluate the effectiveness of ideas and products, elaborate on existing ideas and products, and refine ideas and projects in pursuit of specific end goals" (Mishra & Kereluik, 2011, p. 3308). The Metiri Group call for the development of *Inventive Thinking*. The International Society for Technology in Education (ISTE) highlights the

development of both *creativity and innovation*, while the EU refers to the development of *creativity, Initiative/Entrepreneurship* and P21 has labelled this skill as *Creativity and entrepreneurial thinking*. Making innovative use of knowledge, information and opportunities to create new services, processes and products is essential. The global marketplace rewards organisations that rapidly and routinely find better ways of doing things. Companies want workers who can contribute in this environment.

3. **Becoming smarter about new sources of information:** In this age of potential information overload, students and workers should possess the necessary skills to decipher whether information is reliable or not. "It's important that students know how to manage it [information], interpret it, validate it, and how to act on it," says Dell executive Karen Bruett (Wallis, 2006). P21 has labelled this skill as *Information/ Media Fluency*, the Metiri Group call it *Digital Age Literacy*, ISTE defines it as *Research and Information Fluency* while the EU refers to it as *Digital Competence* and the OECD labels it as *Using tools interactively*. However it is important to note that information literacy "also includes a component of responsible use of technology and media, an important moral and ethical consideration beyond understanding basic ICT systems and media forms" (Mishra & Kereluik, 2011, p. 3306). ISTE refers to this as *Digital Citizenship*.

4. **Developing good people skills:** Good people skills, EQ, or emotional intelligence, are as important as IQ for success in today's workplace. Former Lockheed Martin CEO Norman Augustine believes that "most innovations today involve large teams of people" and "we have to emphasize communication skills, the ability to work in teams and with people from different cultures" (Wallis, 2006). He stresses that all workers need to have good communication skills and be respectful of others.

Communication "involves the ability to clearly articulate oneself through all mediums of communication, oral, written and non-verbal media... including the ability to effectively use digital media to communicate and collaborate with others" (Mishra & Kereluik, 2011, p. 3308). The Metiri Group, P21 and ISTE refer directly to the ability to effectively communicate while the EU stresses the importance of being able to communicate in a variety of languages. Collaboration not only entails being respectful of others but includes being flexible, being willing to participate and recognising the efforts of others. The OECD refers to the development of this skill as *Interacting in Heterogeneous Groups* while P21 and ISTE highlight the ability *to Collaborate*.

The *Time* article is an excellent starting point from which to identify the skills/capabilities that are required for the 21st century workplace. In addition, other necessary skills might include:

5. **Solving complex, multidisciplinary, open-ended problems** that all workers, in every kind of workplace, encounter routinely. The challenges workers face do not come in a multiple-choice format and typically do not have a single right answer. Additionally, "since nearly all of the significant problems of tomorrow are likely to be systemic

problems – problems that can't be addressed by any one speciality – our students will need to feel comfortable working in cross disciplinary teams that encompass multiple ways of knowing" (Seely Brown, 2006, p. 2). Businesses expect employees at all levels to identify problems, think through solutions and alternatives, and explore new options if their original approaches don't pan out. Such critical thinking demands being able to interpret information and make informed decisions based on these interpretations. Often, this involves groups of people with different knowledge and skills who, collectively, add value to their organisations. ISTE, P21 and the EU highlight the importance of such *Critical Thinking, Problem Solving and Decision Making* abilities. The EU also refers to the necessity of being able to engage in *Risk Assessment*.

6. **Life / Job Skills** "are those [skills] that serve to create lifelong learners" (Mishra & Kereluik, 2011, p. 3309). Indeed as Toffler asserts "the illiterate of the 21st century will not be those who cannot read or write but those who cannot learn, unlearn and relearn" (Toffler, 1970). These skills are what the EU refers to as *Learning to Learn*, the OECD labels them *Acting Autonomously*, the Metiri Group defines them as *High Productivity and Quality*, and P21 calls them *Life and Career Skills*. These skills are increasingly important as "most students today aren't going to have a fixed, single career; instead they are most likely going to follow a working trajectory that encompasses multiple careers" (Seely Brown, 2006, p. 2).

In addition to the skills outlined above, "core content knowledge and high academic achievement in traditional domains…are considered to be the foundations upon which other 21st century skills are to be developed" (Mishra & Kereluik, 2011, p. 3306). The Metiri Group stresses the need to attain *High Academic Standards*. The EU refers to the necessity of having *Mathematical and Scientific Competence* while P21 highlights the centrality of Core Subjects, as well as the importance of *Financial and Business Literacy, Environmental Literacy, Civic Literacy and Health Literacy*. Coupled with this is the ability to synthesise information across domains and to apply this knowledge to new contexts. Overall what is needed is "more well-rounded citizens with the skill and outlook to thrive in a future society: people who are interested in the world around them" (Futurelab, 2009, p. 7).

Some may say that many of these skills or capabilities have always been valued and are not unique to the 21st century. Indeed, many of these "skills rather than being novel to the 21st century and necessary for success in the 21st century, are skills that are required for successful learning and achievement in any time, including but not limited to the 21st century" (Mishra & Kereluik, 2011, p. 3310).

However digital technologies allow us to interact with the world in ways that were not possible previously and they result in renewed emphasis on the skills listed above. Increased globalisation and the advent of digital media have meant that people from diverse cultures are now in regular contact with each other. Technologies, such as the Internet, are allowing people to connect and to create new knowledge and meaning that

was not possible in previous generations because these tools did not exist. Successful collaboration however does demand a highly developed sense of "cultural competence" (Mishra & Kereluik, 2011).

Computers, in particular, are transforming the world of work and are taking over many routine cognitive tasks. This in turn is placing a premium on "expert thinking and complex communications" carried out by people (Dede, 2007, p. 8). It is predicted that computers will continue to replace workers engaged in "routine cognitive work and routine manual labour – the types of tasks that are easiest to program computers to do" (Levy & Murnane in Dede, 2007, p. 8). Change is all around us and "students' lives, the lives of teachers, not to mention schools as organisations are being changed by globalisation, technology, changing societal institutions, and the prevailing economic and political climates" (NCCA, 2008a, p. 11). The computerisation of many manual jobs is placing a requirement on all societies to provide our citizens with new skill sets which comprise technical competencies such as computer skills and the 21st century skills outlined above. Students therefore need to develop skills and knowledge that cannot be reduced and reproduced by machines and emphasis needs to be placed on the development of complex cognitive skills, creativity and the ability to effectively communicate and collaborate (Zhao, 2009). Consequently "the mission of schools is to prepare students to work at jobs that do not yet exist, creating ideas and solutions for products and problems that have not yet been identified, using technologies that have not yet been invented" (Darling-Hammond, 2010, p. 2).

Education will play a key role in ensuring our young people are equipped with the necessary skills and knowledge to compete on a global stage in the 21st century. In such a society there will be a strong focus on lifelong learning with workers, including teachers, needing to continuously update their skills throughout their careers. This is increasingly apparent when one considers that knowledge is expanding at a breath-taking pace. For example, in the three years from 1999 to 2002, the amount of new information produced nearly equalled the amount produced in the entire history of the world previously (Lyman & Varian, 2003). As a consequence,

education can no longer be productively focused primarily on the transmission of pieces of information that, once memorised, comprise a stable storehouse of knowledge. Instead, schools must teach disciplinary knowledge in ways that focus on central concepts and help students learning how to think critically and learn for themselves, so that they can use knowledge in new situations and manage the demands of changing information, technologies, jobs and social conditions.

(Darling-Hammond, 2010, p. 4)

In the past students left college and entered the workplace, where they applied knowledge to their jobs, and only occasionally "topped up" their knowledge in subsequent years (Tapscott, 2008; Hagel III et al., 2010). But today and into the future we will need workers who are constantly updating their education and job skills – so they become life-long learners (Dede, 2007).

Rapid technological change and increased international competition spotlight the need for the workforce to be able to adapt to changing technologies and shifting product demand.

(RAND Corporation, 2004, p. 2)

Students therefore need 21st century competencies to survive and thrive in this new type of economy. The education sector "has the role of preparing students for adult life, and, therefore, it must provide students with the skills necessary to join a society where technology-related competencies are becoming increasingly indispensable" (Pedró, 2010, p. 14). They will have to know how to think critically, apply knowledge to new situations, analyse information, understand new ideas, communicate effectively, collaborate, solve problems, and make decisions.

Digital technologies, as the tools of the 21st century, are essential to the development of these skills. Consequently students will need to develop their ability to use digital tools to construct knowledge, to collaborate widely beyond traditional boundaries and communicate effectively and efficiently. The OECD has predicted that "in a knowledge economy driven by technology, people who do not acquire and master these competencies may suffer from a new form of the digital divide that may affect their capacity to fully integrate into the knowledge economy and society" (Pedró, 2010, p. 14).

This begs the question: can our existing education systems meet the challenges we now face in equipping our citizens with these new 21st century skill sets? In the next section the characteristics of the current education system will be examined and we will put forward some examples of innovative and creative learning environments that appear to be more appropriate to meet the needs of 21st century learners.

" What used to be a rather stable setting with fixed roles – educational policy makers setting the scene for learning through curricula; educational publishers developing the learning materials building on the curricula; and schools implementing the curricula issued by policy makers and using the textbooks produced by publishers – is now changing. "

(Hylén, 2010, p. 57)

Learning for the 21st Century

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Many would agree that the industrial model of education, which dominated most of the 20th century, is not appropriate for the 21st century. This model of education focused on preparing citizens to work in factories and other establishments that required repetitive work-related tasks. However, as outlined in previous sections, we live in a global technological world and there is a requirement to change our education system to better meet the challenging needs of living and working in a 21st century global society.

At the same time, new digital divides are emerging, this time dividing those who can master the flow of information, sift, digest and use it, and those who are unable to protect their integrity on the Internet and get lost in the new digital landscape. Education policy makers need to respond to these challenges.

(Hylén, 2010, p. 57)

Many have been critical of the current models of schooling (e.g. Kozma, 2003; Zhao, 2009; Hagel III et al., 2010) and advocate that a fundamental shift in conceptualisation of 'schooling' is needed, which emphasises "higher order cognitive processes such as cirtical thinking, creative problem solving, curiosity and adaptability" (Mishra & Kereluik, 2011). While many schools have introduced changes in terms of the curriculum, ICT and assessment methods, many believe these changes do not go far enough for today's challenges (Dede, 2007; Leland & Kasten, 2002; Tapscott, 2008).

While computers have been introduced into schools, they have been used primarily to improve existing traditional practices (Dede, 2007; Tapscott, 2008, Mulkeen, 2003). Larry Cuban (1993) calls this the "preservationist scenario" where teachers make no substantial changes to the nature of schooling and particularly to teaching, learning and assessment.

The world of business initially adopted a similar approach when IT was first introduced into the sector but today many sectors of the global economy have completely reinvented their business models to take maximum advantage of the technological tools at their disposal (Tapscott, 2008). Education has not, as yet, reinvented itself to take advantage of the technological tools and design learning environments that have the potential to transform education in the 21st century. The need for change is becoming increasingly necessary, for as Papert states "until recently the narrowness and range of the possible doings severely restricted the implementation of the idea. The educational vocation of the new technology

is to remove these restrictions" and enable "a restructuring of knowledge itself" (Papert & Harel, 1991). John Seely Brown supports this assertion stating that "in the net age we now have at our disposal tools and resources for engaging in productive inquiry – and learning – that we never had before" (Seely Brown, 2006, p. 7).

Technology "can provide the necessary tools for improving the teaching and learning process, and for opening up new opportunities and avenues. In particular, it can enhance the customisation of the learning process, adapting it to the particular needs of the student" (Pedró, 2010, p. 14). What is needed is a shift from the predominant 20th century paradigm of "learning about" where the lecture was pre-eminent, to "learning-to-be" (Seely Brown, 2006), the inquiry model which is more in line with the needs of the 21st century. Leland and Kasten (2002) capture some of these changes in the table below.

Table 1 Characteristics of Factory and Inquiry Models

	Industrial Model	**Inquiry Model**
Purpose of education	• Conformity, obedience • Prepare learner for factory job	• Critical thinking, creativity • Prepare learner for information/technology
Learning model	• Behaviourism	• Social constructivism
Structure	• Classes graded by age • Homogeneous groups	• Multiage classes • Heterogeneous groups
Curriculum	• 3 R's, narrow, fact-based	• Multi-faceted, problem solving
Instruction	• Text-based, transmission	• Multiple sources, transaction
Assessment	• Uniform, standardized	• Authentic, diverse
Role of Learner	• Passive, receive knowledge	• Active, construct knowledge
Role of Teacher	• Foreman, clerk	• Co-learner, facilitator
Role of Parents	• Follow dictates of school	• Partner in decision-making
Role of Administrator	• Supervisor, manager	• Instructional leader, co-learner
Type of literacy required	• Decoding, defining, analyzing	• Translation, critical

(Leland & Kasten, 2002, p. 13)

The 20th Century Paradigm

The industrial model was characterised by instilling discipline and obedience in learners to prepare them to perform some relatively easy task over and over again. Young people became 'cogs' in the wheel where discipline and reliability were the core virtues (Reich in Leland & Kasten, 2002). Students were assessed to determine what they lacked and then were "drilled until skilled" (Fosnot in Leland & Kasten, 2002). Society had deemed that the content an educated person should learn was assumed to be universal, all learners received the same curriculum, the 'one size fits all model', with all expected to achieve the same understanding. There was no allowance for individual difference in this model, either in terms of ability or in terms of how relevant the content was for the learner. The content or

the body of knowledge was contained in the textbook and students were expected 'to learn it, receive it and reproduce it' when tested. This paradigm placed enormous pressure on the teacher, often depicted as a 'sage on the stage' who was the fountain of all knowledge. This model of the teacher did not encourage the active discovery and creation of knowledge by both teacher and learner.

Many elements of the industrial model remain in the Irish education system today. Schools are graded by age predominantly and the textbook is still the main medium used to deliver the curriculum. Students, particularly at second-level, spend hours learning off material by rote and are then expected to reproduce it on a terminal or summative exam paper. Yet research has consistently indicated that instruction focussed on memorising unconnected facts and drilling skills out of context produces inert rather than active knowledge, which in turn does not transfer to real-world activities or problem-solving situations (Bransford et al., 1999). Textbook publishers and teachers prepare students to answer questions that may feature on the exam and many students struggle if the questions differ from the expected format.

In contrast, math students in Singapore, Japan, Hong Kong and China, regularly work in pairs or small groups on problems contextualised in real-world situations. Instead of using prescribed formulas, where students have little or no understanding, these students derive formulas after they have deeply understood a mathematical concept and they create their own world problems to test their own and their classmates' understanding further. In this way they gradually come to 'own' the knowledge for themselves (Tsuneyoshi, 2005). It is no coincidence that these students then rank in the top five places respectively in the Trends in *International Mathematics and Science Study* (TIMSS) which assesses how students can apply their understandings.

In Ireland, our state exams at year three (the Junior Certificate) and year six, at the end of second-level (the Leaving Certificate), both place a strong emphasis on factual recall. These exams reward individual performance and do not adequately take into account other forms of assessment. The NCCA and others (Hyland, 2011) are aware of this problem and through their consultations with schools are aware that "students are being taught how to 'get the Leaving' rather than how to develop the skills necessary for life-long learning in a knowledge society" (NCCA, 2008b, p. 7).

The State Exams Commission (SEC) is also aware of this issue. For example, the Chief Examiners Report for Junior Certificate Mathematics in 2006 noted that, "students should not consider mathematics as a list of rules and procedures to be mastered, but should attempt to understand the processes behind them" (SEC, 2006; p. 53). Such observations have informed the NCCA's rationale for introducing *Project Maths, Learning and Teaching for the 21st Century* (Project Maths, 2012) at Junior Certificate level. The NCCA's recent proposals for Junior Cycle reform are an attempt to address the problem of rote learning "while providing for greater creativity and innovation"

(NCCA, 2011a). In addition the NCCA is considering how it can strengthen the development of key skills across the curriculum while also incorporating new modes of assessment that are more relevant and flexible.

The most recent plans, as contained in the Junior Cycle Framework, propose to reduce the number of subjects that students study in order to facilitate more active learning and the embedding of key skills across the curriculum. In addition students can study short courses where the emphasis will be more on project-based learning and on portfolio assessment. Minister Ruairí Quinn has also stressed the importance of strengthening the use of ICT across all subjects. However, there is still much work to be done to convince the teacher unions about such change, particularly in relation to the notion of school-based assessments and the downgrading of the status of the state examination (Burke-Kennedy , 2012).

In order to develop this deeper understanding of 'key concepts', education systems perhaps need to consider the amount of content that is expected to be covered. In Singapore "syllabi, examinations and university admission criteria were changed to encourage thinking out of the box and risk taking" (Ng, 2008b, p. 6). In addition, a plan for infusing technology in every school involved promoting project work and independent learning, with a resulting reduction in 1998 of the content covered by national syllabi. As the Prime Minister of Singapore stated, "we have got to teach less to our students so that they will learn more" (Loong, 2009). Consequently "students are now more engaged in project work and higher order thinking questions to encourage creativity, independent and inter-dependent learning" (Ng, 2008b, p. 6). 'Teach less, learn more' is now a widely used slogan, for as Minister of Education, Tharman Shanmugaratnam explains "the goal is to give the students themselves the room to exercise initiative and to shape their own learning. The students have to become engaged learners – interested and proactive in the learning process." He urged a shift in priorities with

less dependence on rote learning, repetitive tests and a 'one size fits all' type of instruction, and more on engaged learning, discovery through experimentation, differentiated teaching, the learning of life-long skills, and the building of character through innovative and effective teaching approaches and strategies [as well as] holistic learning so that students can go beyond narrowly defined academic excellence to develop the attributes, mindsets, character and values for future success.

(Tharman, 2005b, cited in Ng 2008b, p. 7)

These changes have borne fruit, as is evident from the fact that Singapore has achieved first place in 1995, 1999, 2003 and 2007 in TIMSS tests. In addition

about 90% of Singapore's students scored above the international median on the TIMSS tests. This accomplishment is even more remarkable given that fewer than half

of Singapore's students routinely speak English, the language of the test, at home. Thus Singapore has established itself not only as a centre of mathematics, science and technology but as a nation with fluency in the current and emerging world and regional languages for business and trade.

(Darling-Hammond, 2010, p. 181)

International educational scores (2007)

(8th graders average score, TIMSS International Math & Science Study 2007)					
Country (sample)	Global Rank	Mathematics		Science	
		Rank	Score	Rank	Score
Singapore	1	3	593	1	567
Taiwan	2	1	598	2	561
South Korea	3	2	597	4	553
Japan	4	5	570	3	554
Hong Kong	5	4	572	9	530
Hungary	6	6	517	6	539
England	7	7	513	5	542
Czech Republic	8	11	504	7	539
Russia	9	8	512	10	530
Slovenia	10	12	501	8	538

Similarly, since 1997 the Ministry of Education of South Korea

has been moving assertively to replace what has been characterised as an overcrowded curriculum focused on content coverage with one focussed on deeper understanding of concepts in ways that foster higher order thinking and problem solving skills. The ministry describes the seventh National Curriculum as designed to address the needs of a global knowledge based economy, developing students' abilities to think originally, to create knowledge and to communicate that knowledge effectively to others. Infusion of technology is an additional goal. Every Korean school had high speed Internet connections in classroom by 2002, and ICT usage must be incorporated into at least 10% of every subject. Current reforms aim to better develop core competencies such as higher order thinking, self-control, responsibility, independence, creativity, self-directed learning capabilities and social capital development.

(Darling-Hammond, 2010, p. 178)

These ambitious reforms have resulted in South Korea now ranking in first place in reading and fourth place in mathematics in the latest published PISA results.

PISA 2010 International Rankings

How 15-year-old pupils compared	
Reading	**Mathematics**
Above average:	
South Korea	Taiwan
Finland	Finland
Hong Kong – China	Hong Kong – China
Canada	South Korea
New Zealand	Netherlands
Ireland	Switzerland
Australia	Canada
Liechtenstein	Macao – China
Poland	Liechtenstein
Sweden	Japan

The examples outlined above from countries which rank in the top places in TIMSS and PISA indicate that when reforms were initiated that reduced the amount of content and instead placed the focus of teaching on an in-depth understanding of content in contextualised real-world situations, learners engaged at a much deeper level. Coupled with these reforms was a focus on the infusion of technology into the learning environment.

How then do we learn from these experiences of other countries and design learning environments that will help prepare learners for this global world which requires skilled communicators and complex thinkers who are fluent in using a myriad of other high-level skills and competencies?

The next section examines a core set of characteristics of the learning environment which we believe is conducive to developing the skills and competencies required of the lifelong learner in the 21st century.

The 21st Century Learning Environment

In contrast to the industrial model, 21st century learning environments should be predominantly inquiry based where students and teachers make decisions about how they and others will spend their time in class. In such learning environments students are actively involved in the learning process. Teachers and students construct knowledge by drawing on their experiences with or without the guidance and support of others (Weaver in Leland & Kasten, 2002).

Characteristics of a 21st Century Learning Environment

- They are teaching and learning communities where students are actively engaged in learning with teachers;
- They create an environment that guides and supports self-directed learning;
- They enable effective relationships between students and their teachers;
- They support differentiated instruction that includes distributed learning, cross-curriculum links, diverse instructional groupings, and diverse broad-based assessment;
- They use professional development for site-based research and for opportunities for on-site application, discussion, research, and reflective practice to build knowledge throughout the school;
- They integrate feedback from students, parents and other stakeholders and evaluate and analyse change over time.

(McGinn, 2007)

21st century learning environments are predominantly learner-centred and teachers are attentive to students' knowledge, skills, attitudes and beliefs. Students are encouraged to ask questions and engage in social discourse, and find out their own answers. In such settings the teacher's role changes to that of 'co-constructor' of knowledge, rather than transmitter of content.

This co-construction approach is evident in Aistear, the NCCA's early childhood curriculum framework. Aistear highlights the importance of reciprocity in adult-child interactions:

During early childhood it is important that children have opportunities to lead learning through self-initiated and self-directed learning, and to be involved in decisions about what they do. At other times, the adult leads through planned and guided activities and increases or lessens the amount and type of support as children grow in confidence and competence.

(NCCA, 2009b, p. 28)

The NCCA also advocates a co-constructor approach in its Key Skills Project, and this appears to be having very positive results for both teachers and students.

> They (students) wanted to prove that the change in teaching style was in fact helping them to learn more effectively, and as a result students were more inclined to work with you rather than against you. When they felt involved, students felt more in command of their learning. They took greater responsibility, were more positive, and very cooperative (Irish teacher).
>
> (NCCA, 2008a, p. 30)

By comparison, the Primary School Curriculum emphasises the teacher's role to a greater extent in guiding learning whereby the adult identifies "particular stages of development in the child's understanding and then choose the sequence of activities that will be most effective in advancing the child's learning" (Government of Ireland, 1999, p. 15).

It may be time to revisit the Primary School curriculum's principles and establish a more coherent connection between those outlined in Aistear and the Key Skills project.

Characteristics of a 21st Century Teacher

The role of teachers changes in this new paradigm; they are no longer viewed as a fountain of knowledge, breaking knowledge up into bite-sized chunks and transmitting it to their students. Their new role is more demanding and more complex. They are seen to:

- Be knowledgeable about how students learn and understand available resources (including ICT)
- Be involved in reflective practice.
- Adopt a collaborative approach that embraces change and flexibility of methodology.
- Develop productive relationships with students that support their engagement with learning.
- Practice differentiated instruction that encompasses distributed learning, diverse evaluation and diverse groupings.

(McGinn, 2007)

Teaching in the 21st century requires committed teaching professionals who are constantly updating their own knowledge and skills and applying these in their everyday teaching. The notion of a teacher as a 'learner' is at the heart of learning in the 21st century (Barber, 1996; Butler, 2004).

Westbury et al. (2005) have suggested that the preparation of teachers for a research-based

profession has been the central tenet of teacher education development in Finland. Teachers are trained in research methods of planning, action, and reflection/evaluation so that they can "contribute to an increase of the problem solving capacity of the education system" (Buchberger & Buchberger, 2004, p. 10).

All Finnish teachers now complete a master's thesis that involves them in research on practice focused on developing teachers' deep understanding of the principles of learning which allows them to create "powerful learning environments" that continually improve as they learn to engage in a "cycle of self-responsible planning, action, reflection/evaluation" (Buchberger & Buchberger, 2004, p. 10).

> *Investment in teachers has also been an important linchpin of South Korea's stunning climb from an uneducated population to one of the top ranked nations in the world educationally.*
>
> *(Darling-Hammond, 2010, p. 173)*

In Singapore, pre-service teachers are engaged in the

> *kind of inquiry and reflection in which they are expected to engage their students in the schools, so that they can teach for independent learning, integrated project work and innovation. Candidates learn to teach in the same way they will be asked to teach. Every student has a laptop and the entire campus is wireless. After initial preparation, as in other highly ranked countries, expert teachers trained by the National Institute as mentors are given release time to help beginners learn their craft. Thereafter, the government pays for 100 hours of professional development each year for all teachers in addition to the 20 hours a week they have to work with other teachers and visit one another's classrooms to study teaching.*
>
> *(Darling-Hammond, 2010, p. 190)*

When one compares this level of investment in teachers' development to what is generally experienced in other countries it is not surprising that Singapore is leading the way in many aspects of teaching and learning.

Change is constant for teachers, whether it is the introduction of new technologies, new learning theories or assessment techniques. They need support in introducing these changes into their own classrooms and ultimately embedding them into their practice. Such change is not easy and it takes time and effort on the part of the teacher.

"In Finland, like other high-achieving nations, schools provide time for regular collaboration among teachers... [they] meet at least one afternoon each week to jointly plan and develop curriculum" (Darling-Hammond, 2010, p. 172). Time is also provided for professional development within the teachers' work week.

In Korea, as in Japan and Singapore, only 35% of a teacher's working time is spent teaching

pupils. Teachers work in a shared office space during out-of-class time which facilitates the sharing of instructional resources and ideas among teachers which is especially helpful for new teachers (Kang and Hong, 2008).

This however is not the case in many countries, as illustrated by a quote from an Irish teacher below:

> *They [teachers] also spoke of the difficulties of finding time to reflect due to the pressures of the teaching day and a school climate where the rapidly changing Ireland is forcing teachers to manage a very diverse classroom with little support. In the intensity of the school day, it is virtually impossible to reflect and plan (French language teacher).*

> *(NCCA, 2008a, p. 37)*

This teacher's perspective highlights the challenges facing many teachers today and it illustrates the difficulties they face in implementing changes in their classrooms. There is extensive literature on models of educational change: Diffusion of innovations (Rogers, 2003); Conditions of change (Ely, 1990); Change agent's guide (Havelock and Zlotolow, 1995); Concerns-based adoption model (Hall & Hord, 1987); the contextual levels (Macro, Meso, Micro) that affect and mediate change (e.g. Cole, 1996) as well as the challenges of initiating and sustaining educational change in schools (c.f. Ellsworth, 2000a and 2000b; Fullan, 2001; NCCA, 2009a) a process which is often further complicated with the introduction of digital technologies (Zhao et al, 2002; Jones, 2004; Somekh, 2007).

This research literature offers invaluable guidance not only to policy makers but also to school leaders and teachers as to how to create conditions that are conducive to achieving and sustaining deep and continual change more effectively in the varying contexts in which schools are working today.

Australia provides a strong example of how teachers have been consistently supported to meet the challenge of this change process. Firstly formal recognition for the importance of ICT in education was firmly established in the Adelaide Declaration of Australia's National Goals for Schooling by the statement that when students leave school they should be: "confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society" (MCEETYA, 1999). To realise this goal, a school education action plan titled *Learning in an Online World* (MCEETYA, 2000) was developed, later updated as *Contemporary Learning: Learning in an Online World* (MCEETYA, 2005).

These plans prioritised areas for strategic development to support teachers in coping with the challenges that the introduction of these new technologies posed including:

- developing teacher competence in using learning technologies effectively;
- implementing an advanced ICT infrastructure for education;

- developing online resources for curriculum, teaching, and administration;
- facilitating the uptake and use of ICT in schools; and
- establishing a framework to support the use of ICT to enhance learning.

(Ainley, 2010, p. 71)

At the end of 2007, the federal government proposed a 'digital educational revolution' (DER) as "a centrepiece of its education platform" that "aims to support change to teaching and learning in Australian schools, ensuring that students undertake stimulating learning activities that are supported by access to global information resources and tools for information processing" (Ainley, 2010, p. 74). To achieve this, they provided new ICT equipment for all second-level schools, deployed high-speed broadband connections to schools and provided online curriculum tools and resources that support the national curriculum. Significantly, they also established competency in ICT as a graduation requirement for all new teachers and "on-going progressive development of the capacity of existing teachers" so that they can "devise student-centric programmes of learning based on established curriculum standards and supported by contemporary learning resources" (Ainley, 2010, p. 74). The

Australian school systems operate professional learning programmes to extend the ICT competences of teachers. Some school systems use in-school professional learning models based on mentors. Others have developed various forms of "centres of excellence," that is, lighthouse or navigator schools, which serve as models of good practice and providers of professional development for teachers in surrounding schools. Some school systems reached agreement with local universities to ensure that pre-service ICT course content aligns with the needs and actual situations new teachers encounter in schools.

(Ainley, 2010, p. 73)

An evaluation plan has been developed to track progress and monitor the effectiveness of the DER (MCEETYA, 2008). This comprehensive process is intended to enrich student learning. However, to do this effectively there needs to be an understanding of who these students are and how they differ from previous generations of learners.

Characteristics of a 21st Century Student

The world of our students is very different from the world of many of their teachers – they are members of a generation that has grown up with the Internet and an ever-expanding range of communication and collaboration tools.

They want to learn, but they want to learn only what they have to learn, and they want to learn in a style that is best for them.

(Sweeney in Tapscott, 2008, p. 130)

" They want to learn, but they want to learn only what they have to learn, and they want to learn in a style that is best for them. "

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Project Tomorrow (2009) found that parents and students agreed that schools are not preparing students for the 21st century. The report also found that parents want to see more technology in their children's schools. Parents "are strongly in favour of schools adopting 21st century technology-infused approaches to teaching and learning...ranging from online textbooks to more use of tools such as Interactive white boards, laptops for students, computer projection devices and technology-based organizational tools" (Project Tomorrow, 2009, p. 1). Both parents and students agree that technology is essential to learning.

However it was noted that parents and students approach the use of technology differently. Parents view technology as supporting traditional teaching approaches while students are seeking more collaborative tools that support inquiry-based learning. Parents also believe that information literacy is crucial to their children's success. By information literacy they mean "the ability to conduct research, find, organize and summarise data and develop media literacy skills" (Project Tomorrow, 2009, p. 2). It appears that today's students need a different paradigm of learning from the one they typically experience within educational institutions.

This proposed paradigm shift should enable them to:

- Experience joy, satisfaction and passion for academic excellence and life-long learning;
- Actively engage in learning – both in and out of school;
- Accept ownership of their learning – that involves the ability to be self-directed, a decision-maker, and a manager of priorities in and out of school;
- Use technology to achieve personal learning goals and to succeed in various learning activities;
- Learn multiple languages and develop an appreciation for cultural patterns and expectations;
- Access learning opportunities that involve multiple modalities and include choice.

(McGinn, 2007)

Students appear to enjoy this new educational paradigm as evidenced by the following quote from students in Ireland participating in the NCCA's Key Skills Project:

I definitely prefer being taught this way because you are more inclined to think through what you are doing and make sure you understand it fully (Mathematics student).

You understand and it is not just notes in a hardback (Biology student).

(NCCA, 2008a, p. 29)

Learning for the 21st Century
– What does it look like?

In this section we describe a number of examples from Ireland and the U.S. to illustrate how a small number of institutions and school systems are already designing learning environments which reflect this paradigm shift.

eMINTS Project

eMINTS began as an initial demonstration project conducted in 1997 and is now a large-scale programme involving more than 16,000 students in classrooms across Missouri (Kleiman, 2004). The project's mission is to support Missouri educators as they integrate multimedia technology into inquiry-based, student-centred, interdisciplinary, collaborative teaching practices that result in higher levels of student performance. Teachers in the project engage in more than 250 hours of professional development over a two-year period to help them learn new teaching strategies using multimedia technologies. The support infrastructure includes classroom visits, and on-going support from instructional specialists. The programme places a strong emphasis on 'just-in-time' supports as they see these as essential to enable teachers transform their practice. The project goes far beyond providing technology for classrooms; there is a strong pedagogical focus coupled with an extensive professional development and classroom-coaching programme.

The findings from two eMINTs studies (academic years 2000-2001 and 2001-2002) provide evidence of its impact on student learning (Kleiman, 2004). The studies found that students who participated in inquiry-based learning with ICT scored higher on State-mandated standardised tests. The studies also found that the role of the school principal was a key factor in promoting an inquiry-based learning approach across the participating schools and strong leadership resulted in students performing better on the State assessments (Kleiman, 2004, p. 7).

This research suggests that if inquiry-based learning approaches are embedded in classroom practice students will perform better. Central to bringing about such change is the investment in the development of human capital through quality professional development programmes. This echoes calls from the Irish National Competitiveness Council (2009) which has requested increased funding for teacher professional development, even in these demanding economic times.

Others such as Tapscott (2008) urge schools not simply to put hardware into schools but to combine it with good pedagogy, such as inquiry-based learning. The evidence from this and other projects, such as the iSchool Project in New York City (NYC iSchool) and

Futurelab's Enquiring Minds Project in Bristol, suggests that it is essential to provide a sustainable framework for quality continuous teacher professional development if we are to successfully design 21st century classrooms, where ICT is truly embedded.

Empowering Minds Project

The Empowering Minds (EM) Project is a successful Irish example which empowers teachers to design 21st century classrooms, where the use of digital tools is truly embedded in learning (Butler, 2007). The Empowering Minds Learning community uses the constructionist approach developed by Professor Seymour Papert of MIT's Medialab, and pioneered in Ireland by Dr Deirdre Butler at St Patrick's College, Drumcondra. The EM project began in 1999 with a core group of four schools (urban-disadvantaged, suburban-advantaged, typical suburban and rural) and eight teachers. In the following year, the project expanded to twelve schools including more small rural schools and disadvantaged schools, as well as some single sex schools and children with special needs. The EM community has grown steadily since 2002 to include teachers and children from 60 schools with the more experienced teachers supporting the new teachers.

Empowering Minds was founded on three core principles (Butler et al. 2000; Martin, et al. 2000):

1. To encourage children and teachers to develop technological fluency with project-based learning;
2. To use technology as an integrating agent for learning;
3. To establish a new model of teacher professional development, in which teachers are centrally included in the process of pedagogical activity design.

An example from one of the classrooms in the EM community will be highlighted here as the teacher, Kate O'Connell, was the 2008 recipient of Microsoft's European and World Innovative Teacher Award. Kate and her class in Kilvemnon National School, a small rural primary school, received the award for their work on their 'Flying High' Project, which integrated ICT into every subject in the primary school curriculum. Kate teaches in a two-teacher school. The pupils explored various aspects of aviation for this project. They established their own learning goals and were responsible for the most part in directing their own learning. Working collaboratively they used a range of digital tools (computers, digital cameras for still images and video recordings, MP3 players and voice recorders), freely available software (Audacity, Irfanview, PhotoStory and Windows MovieMaker) and Web resources (flight simulation games, Google Earth and Virtual Earth) to construct their own understandings and knowledge.

As part of this process the pupils learnt about the importance of citing references and "the difference between research and blind plagiarism" (O'Leary and O'Mahony, 2010, p. 232).

In the course of their research they also learned skills for safe Internet use, such as using suitable nicknames when blogging and how to protect their own private information. They used Web 2.0 tools such as blogs and podcasts to publish their work to a global audience. The pupils also worked in teams to construct their own working models of aeroplanes and they programmed them to work using the LEGO Mindstorms Robotics System. Kate stated "I feel that it is important for children to learn through a hands-on approach. They are more likely to understand a problem when they have worked through it rather than been talked through it" (Ibid; p. 233).

Kilvemnon National School is a rich learning environment where pupils are actively engaged in their own learning and in negotiating its direction with their peers and class teacher. The pupils are active and they construct knowledge by engaging with 'real world' experts and their peers. The pupils emailed experts in NATO, the RAF, the Irish Air Corps, Shannon Aerospace and others as part of their project and they even organised a visit from a former pilot. On reflection, Kate noted that the approach to learning "enhanced children's own learning styles and helped to create independent thinkers. It also developed each child's self-confidence and has given them a sense of pride in themselves and in their school" (Ibid, 234). She reflected "using ICT has been a cohesive factor in the classroom giving each child an opportunity to achieve success at their own level, and has proved to be the decisive factor in motivating students who previously were under achieving or unwilling to contribute" (Ibid; p. 232).

This classroom example from Kilvemnon National School illustrates that the learning environment enabled students and teachers to learn side-by-side about robotics and computer programming, in creative contexts that invoke and depend as much on arts, history and culture as on science and engineering. It is typical of all EM classrooms which are studio-style, constructive learning environments that are more akin to artists' studios than traditional classrooms (Butler, 2007, Butler & Kelly, 2007). Each learner decides what projects to work on and therefore the contents of the learning and how to approach and express it. People across generations and with multiple learning styles have access to the community, the materials and the concepts that the materials afford. Decision-making within the community is democratic. These methods emphasise dignity, equity and inclusion, promoting the values of control and ownership as well as developing a wide range of the skills identified earlier in this paper as being essential for living and learning in the 21st century.

Microsoft Partners in Learning (PIL)

The Partners in Learning for Schools programme helps school leaders develop a vision to transform their school community into an environment that fosters 21st century learning and innovative teaching practices. The programme aims to discover, share, and scale best practices, develop models, and assets that any school/school system can use to help students

achieve their full potential, and create a collaborative community of like-minded school leaders.

There are currently 7,000 schools participating worldwide in more than 60 countries. From these schools 161 have been awarded Pathfinder status and 74 Mentor status.

Through Partners in Learning, Microsoft helps school leaders increase innovative teaching and learning practices by creating a culture empowered by technology that further enables students to develop 21st century skills via:

• Promoting the innovative use of technology and overall learning development;

• Supporting leaders to successfully build teacher capacity to improve innovative teaching and learning practices;

• Inspiring leaders to think big as well as discover and implement best practices to increase innovation in their schools.

Listed below is a selection of case studies (Microsoft Partners in Learning, 2012) from a number of these innovative schools round the globe which will give a flavour of the range of innovative practices that are being developed to meet the challenge of preparing students for the globalised connected world of the 21st century.

• Partners in Learning - Eunice School, South Africa
  o http://www.youtube.com/watch?v=Q5Tajb6jYVA

• Partners in Learning - Fontan School, Columbia
  o http://www.youtube.com/watch?v=QsOvh_l_RE4

• Partners in Learning - Ritaharju Finland
  o http://www.youtube.com/watch?v=cv_OqRHoP9E

As part of the Microsoft Partners in Learning portfolio, other resources are also available – at no cost – that connect school leaders and educators and help transform their school communities.

Microsoft Partners in Learning: http://www.pil-network.com/

• Connect, collaborate, create, and share so students can realise their greatest potential.

Innovative Teaching and Learning Research: http://www.itlresearch.com/

• ITL Research is a multiyear global research program designed to investigate the factors that promote the transformation of teaching practices and the impact those changes have on students' learning outcomes across a broad range of country contexts.

Microsoft Innovative Schools Toolkit: http://www.is-toolkit.com/

• Available online, the toolkit is a practical guide and is customisable based on your needs. The toolkit is divided into four sections: self-reflection; case studies; knowledge library, and practical workshops.

"A Silicon Republic article entitled, *Talent and Education* (Kennedy, 2009), highlighted the need for students to leave school equipped with the necessary skills to function effectively in a 21st century global economy. The article stated that "computing, maths and science skills, teamwork capability and critical thinking [are] needed for success in the modern world". The article noted that "smart kids tooled up with the latest technologies are the surest route to economic success in the next 20 years""

(Kennedy, 2009b)

Conclusion

A Silicon Republic article entitled, Talent and Education (Kennedy, 2009), highlighted the need for students to leave school equipped with the necessary skills to function effectively in a 21st century global economy. The article stated that "computing, maths and science skills, teamwork capability and critical thinking [are] needed for success in the modern world". The article noted that "smart kids tooled up with the latest technologies are the surest route to economic success in the next 20 years".

(Kennedy, 2009b)

So what can we do to create schools where all students can experience learning environments that promote the development of 21st century skills? Is it simply to invest in procuring more technology for schools?

Many do not believe this is the answer (Kennedy, 2009b; Tapscott, 2008), as just having technology in schools does not by itself lead to changes in learning outcomes (Dynarski et al., 2007). It does not mean that educators will use technology or meaningfully integrate it in teaching and learning (Cuban et al., 2001; Bebell et al., 2004). In addition, "a significant body of research shows that how technology is used can determine whether or not its use affects learning outcomes" (Wenglinsky, 2005 as cited in Langworthy et al., 2010, p. 109). We need to examine more holistically the mismatch between what today's students need for tomorrow's world and what many education systems currently provide.

We need to critically think about what kind of infrastructure needs to be developed to take cognisance of the complex interface between learners, curriculum, pedagogy, contexts for learning, and teachers themselves including their beliefs, attitudes and dispositions. Only then will we be in a position to begin to imagine the kind of school system we need to create to develop students who are adequately prepared to live and learn in the 21st century.

There are elements of this new type of school system already emerging, particularly through the work of organisations such as the NCCA in Ireland and through innovative pilot programmes, such as Empowering Minds and The Digital Hub Learning Initiatives.

The problem is that many of these initiatives tend to operate independently of one another and are not informing national policy and their associated implementation plans. Yet it appears that a combination of small-scale developmental initiatives combined with progressive national strategies is what is needed to transform the Irish education system. Both the developmental initiatives and the national strategies need to combine the innovative use of ICT with progressive policy approaches – it should not be an either/or approach.

For example, the NCCA's Project Maths (PM) has moved from being a pilot project to a national initiative and has been rolled out in all post-primary schools since September 2010. Though the initiative has been welcomed in many quarters ICT only plays a limited role in how teachers teach and assess the programme. The Project Maths curriculum is not dependent on levels of ICT provision as the Department has deemed that schools currently do not have sufficient infrastructure (Flynn, 2009b). Yet this lack of infrastructure is potentially restricting how teachers and students might interact with the curriculum in new and innovative ways.

Separately, the Department of Education and Skills is rolling out high-speed broadband to all second-level schools in Ireland. This initiative is also to be welcomed and will provide teachers and students with access to high-speed broadband connectivity, which opens up new possibilities for teaching and learning. Unfortunately to date this initiative has focused primarily on connecting schools to the network and there has been little or no discussion on how it can transform how teachers teach and students learn. In this case the policy of extending broadband reach has not been linked to wider educational policies; it is viewed as a standalone IT project, which is regrettable.

Though Project Maths is an innovative approach to the teaching of mathematics in a 21st century society it plays down the role of technology, while the broadband rollout has primarily focused on the connection of schools to the national grid. Yet there is growing evidence that technology presents teachers and students with additional rich learning opportunities (Laurillard and Masterman, 2010) and surely there is a need to exploit these new opportunities. There is further evidence that teachers need assistance to design teaching, learning and assessment activities that effectively utilise these new technologies (Laurillard, 2012). We certainly need to provide teachers with greater support to share their professional practice knowledge in relation to how they design effective teaching events.

It is no longer appropriate to discuss teaching, learning and assessment without including ICT and conversely it is no longer appropriate to discuss infrastructure without focusing on teaching, learning and assessment. Therefore there is a need to initiate new conversations where innovative teaching, learning and assessment practices are discussed in the context of new digital technologies. Although this is an ever-changing picture, innovative pilot programmes should inform these inclusive discussions so that schools are supported to implement new innovative practices designed to meet the needs of 21st century learners and society.

What is really necessary is a systemic change agenda – one that will transform our schools into 21st century learning spaces. However we need to be mindful that "educational change is complex and takes place within existing complex ecosystems of influences that include

national policies and programmes, support from local communities, school-specific cultures and leadership, and the inexhaustible diversity of individual educators and learners" (Langworthy et al., 2010, p.108). Policy makers and government agencies on their own cannot bring about this change as it will require a combined effort of parents, teachers, learners, social partners and industry.

Agencies such as the NCCA are providing leadership and guidance in areas such as early childhood education (NCCA, 2009b), and in attempting to reform junior and senior programmes through initiatives such as Key Skills, but others also need to be involved.

For example, Government can play a key leadership role by consulting with a wide range of stakeholders to define what a 21st century school should look like. It is heartening to read in the *Programme for Government* (Government of Ireland, 2011) that the practice of treating ICT as a standalone issue will cease during the lifetime of this administration. The Department of Education and Skills has already begun to integrate ICT further into teaching, learning and assessment by the merger of the National Centre for Technology in Education (NCTE) with the Professional Development Service for Teachers (PDST). However, the Programme for Government also promised a new plan in relation to how ICT could be better integrated across the education system and we still await this plan. Yet Minister Quinn appears to recognise that ICT has to play a more central role in redefining teaching, learning and assessment and it is now time to explore what this might look like in reality.

We would argue that instigating a fundamental change programme will require leadership from the Taoiseach and a number of key cabinet ministers (e.g. Communications, Finance and Jobs, Enterprise and Innovation), working in partnership with the Minister for Education and Skills. We are of the view that this approach is central to initiating and sustaining the development of an action plan that will have a significant impact.

It involves seeing schools as centres of innovation and learning and empowering them through investment, support and knowledge management to realise that role. Policy priorities and change strategies in education should be orientated in this context. [However] clear policy frameworks and thinking provide the best basis for the introduction of particular strategies for change and areas of change, and for enhancing the role of schools in this context.

(NCCA, 2009a, p. 20)

Ireland is fortunate in currently having a highly educated teaching force (OECD in NCCA, 2008a) and sustained investment in our education system is acknowledged as having played a key role in attracting foreign direct investment into Ireland

(Thornhill, 2009). We now have an opportunity to take stock of our education system and to plan for the future. Dr John Sweeney, of the National Economic and Social Council, speaking at an event entitled 'Creating an Inclusive Smart Economy' spoke about the need to revamp our education system at first level in order to create an inclusive, smart economy (Sweeney, 2009). In revamping or reinventing our education system we need to consider what role ICT will play in reshaping the experiences of the teachers and the students.

Both the current and previous government administrations have acknowledged the key role education will play in preparing Ireland to emerge from the current global recession (Government of Ireland, 2008; Government of Ireland, 2011). In particular the current administration's *Programme for Government* (Government of Ireland, 2011) speaks of 21st century schools and of building schools for the future. Again such promises are to be welcomed as they recognise the need for our education system to better reflect the technological advances which Irish society has embraced. Interestingly, the *Programme for Government* also highlights the need to reform third level; but why not reform the entire system – from first to third – so that our entire system is fit for purpose? The challenge now is to further define these promises and to develop realistic implementation plans that take these ideas forward.

Other countries, such as Finland and Singapore, have developed coherent visions and implementation plans and as a result these countries are reaping the rewards today. We also need to look to research which can offer a global perspective (e.g. the international research project called *Innovative Teaching and Learning (ITL) Research*, led by Stanford Research Institute, (www.itlresearch.com). The ITL Research project studies what works at the system, school, educator, classroom and student levels and

aims to develop and contribute [to the public domain] a set of tools to measure educators' adoption of innovative teaching practices and the degree to which those practices provide students with learning experiences that promote the skills they will need to live and work in the 21st century. The project could provide education policy makers with both new measurement tools and descriptions of how technology can be integrated into teaching and learning to achieve desired student learning outcomes.

(Langworthy et al., 2010, p. 107)

It is hoped that this ITL Research will "bring new insights to governments' and schools' efforts to innovate in education. ITL can also provide a common language that supports international dialogue on what is working, what needs reform, and how much progress is being made toward educational transformation" (Langworthy et al., 2010, p. 120).

Ireland is a small country and we can use our size as a major positive in bringing about this change. We need to focus greater attention on the structural obstacles to our education system 'being smarter' e.g. teacher education and professional development, the pivotal role of the points system, lack of investment in schools and lack of autonomy for schools at a local level.

It will not be easy but that should not deter us from energising all those involved in education to engage in a meaningful discussion and significant rethinking with regards to the future of our education system. This has to be more inclusive than the premise that certain education inputs will give rise to a certain scale and type of economic development. The relationship between the two is far less direct, controllable and predictable than many often imply. As educators we have to ask the questions: what kind of future do we want to create for our students, what kind of people do we want to nurture and what values do we want to live by? However, we then need to create a school system that enables us to engage in a learning process that is not just about valuing what we do, but doing what we value.

We agree with Hargreaves and Shirley (2009) when they write: "The Fourth Way is a way of inspiration and innovation, of responsibility and sustainability...it brings together government policy, professional involvement, and public engagement around an inspiring social and educational vision of prosperity, opportunity, and creativity in a world of greater inclusiveness, security and humanity" (p. 71). To make the quantum leap to a new paradigm in our education systems we require the combined effort and vision of many.

It has been said that no man is an island. This is also true when it comes to technology-based innovation in education. No actor or group of stakeholders can secure success and sustainability in this domain by themselves. 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.

(Johannessen & Pedró, 2010, p. 158)

References

Ainley, J. (2010). 'Monitoring and assessing the use of ICT in education: The case of Australia'. In OECD (Ed.), *Inspired by Technology, Driven by Pedagogy: A Systemic Approach to Technology-Based School Innovations* (pp. 67-88). Paris, France: OECD Publishing.

Associated Press. (2009). Obama: *'We've let our grades slip'* [Online]. Available at: http://www.msnbc.msn.com/id/29612995. [Last accessed May 2012].

Australian Government (2009). *Building the Education Revolution - Overview.* [Online]. Available at:
http://www.deewr.gov.au/Schooling/BuildingTheEducationRevolution/Pages/default.aspx. [Last accessed May 2012].

Australian Government. (2011). *Digital Education Revolution Homepage.* [Online]. Available at: http://www.deewr.gov.au/Schooling/DigitalEducationRevolution/Pages/default.aspx. [Last accessed August 2011].

Barber, M. (1996). 'New Teachers for a New Century': *The Learning Game: Arguments for an Education Revolution* (pp. 206-238). London: Gollancz.

Bebell, D., Russell, M. and Dwyer, L. M. (2004). 'Measuring teachers' technology uses: Why multiple-measures are more revealing'. *Journal of Research on Technology in Education*, 37 (1), 45-63.

Bransford, J. D., Brown, A. L. and Cocking, R. R. (1999). *How People Learn: Brain, Mind and Experience.* Washington, DC: National Academy Press.

Buchberger, F. and Buchberger, I. (2004). 'Problem-solving capacity of a teacher education system as a condition of success? An analysis of the "Finnish Case" '. In F. Buchberger and S. Berghammer (Eds), *Education policy analysis in a comparative perspective.* Linz, Austria: Trauner.

Burke-Kennedy, E. (October 4, 2012). 'Teachers' unions criticise Junior Cert plan'. *Irish Times.*

Butler, D., Martin, F. and Gleason, W. (2000). *Empowering minds by taking control: Developing teachers' technological fluency with LEGO Mindstorms.* Paper presented at the SITE Conference. Charlottesville, VA.

Butler, D. (2004). *Reconceptualising Teacher Learning in a Digital Context. Proceedings of the Society for Information Technology and Teacher Education Conference.* Paper presented at the SITE Conference. Atlanta, Georgia

Butler, D. (2007). 'A constructivist view of what it means to be digitally literate: Learning in 21st century classrooms'. *The Nordic Journal of Digital Literacy*, 2, 61-77.

Butler, D. and Kelly, J. (2007). 'The Digital Era: Empowerment or Digital Divide'. In P. Downes and A. L. Gilligan (Eds), *Beyond Educational Disadvantage*. Dublin: IPA.

C2K (2011). *Business Plan 2010-2011*. Belfast: C2K.

Christensen, C., Horn, M. and Johnson, C. (2008). *Disrupting Class: How Disruptive Innovation will change the way the world learns.* New York, NY: McGraw Hill.

Cole, M. (1996). *Cultural Psychology: A once and future discipline.* Cambridge, MA: Harvard University Press.

Cuban, L. (1993). Computers Meet Classroom: Classroom Wins. *Teachers College Record*, 95 (2), 185-210.

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

Darling-Hammond, L. (2010). *The Flat World of Education: How America's Commitment to Equity will determine our future.* New York, NY: Teachers College Press.

Dede, C. (2007). Transforming Education for the 21st Century: New Pedagogies that Help All Students Attain Sophisticated Learning Outcomes. Harvard University: Commissioned by the NCSU Friday Institute.

Department of Education of Northern Ireland (DENI) (1997). *A Strategy for Educational Technology in Northern Ireland*. Belfast: DENI.

Department of Education Northern Ireland (DENI). (2004). Empowering Schools Strategy: Belfast: DENI.

Department of Finance (2011). *Jobs Initiative.* Dublin: Government of Ireland.

Dulye, L. (2008). *Using communication to drive change at Rolls-Royce.* [Online]. Available at: http://news-business.vlex.com/vid/using-communication-drive-rolls-royce-65685933. [Last accessed February 2012].

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.

Education Commission Hong Kong. (2003). *Progress Report on the Education Reform (2): Learning for Life; Learning through Life.* [Online]. Available at: http://www.e-c.edu.hk/eng/reform/progress/progress03_full_eng.pdf. [Last accessed November 2012].

Ellsworth, J.B. 2000a. Surviving Change: A Survey of Educational Change Models. ERIC Clearinghouse on Information and Technology, Syracuse, NY.

Ellsworth, J.B. 2000b. A Survey of Education Change Models. [Online]. Available at: http://www.ericdigests.org/2001-2/survey.html. [Last accessed November 2012].

Ely, D. 1990. Conditions that facilitate the implementation of educational technology innovations. Journal of Research on Computing in Education. 23 (2), 298-305.

ETS. (2002). *Succeeding in the 21st Century, What Higher Education Must Do to Address the Gap in Information and Communication Technology Proficiencies.* Princeton, NJ: ETS.

European Commission. (2008a). *Cluster Key Competences – Curriculum Reform Synthesis Report on Peer Learning Activities in 2007:* Directorate-General for Education and Culture.

European Commission (2008b). *An Updated Strategic Framework for European Cooperation in education and training.* Brussels: Communication from the Commission of the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Training Agency (2010). *Key Competences.* [Online]. Available at: http://www.etf.europa.eu/web.nsf/pages/Key_competences_EN?OpenDocument. [Last accessed May 2012].

Finnish National Board of Education (2007). *Competence-based Qualifications 1st January 2007.* Helsinki: Finnish National Board of Education.

Flynn, S. (Thursday September 24, 2009a). 'Group to discuss plans to overhaul Junior Cert'. *Irish Times.*

Flynn, S. (Wednesday October 21, 2009b). 'New Math course hit by lack of school computers'. *Irish Times.*

Flynn, S. (Tuesday April 6, 2010). 'HEA calls for 'overhaul' of Leaving Cert Exam'. *Irish Times.*

Forfás Expert Group on Future Skills Needs. (2007). *Tomorrow's Skills: Towards a National Skills Strategy.* [Online]. Available at: http://www.skillsstrategy.ie. [Last accessed November 2012].

Forfás. (2009). *Skills Opportunities Identified by Expert Group* [Online]. Available at: http://www.forfas.ie/media/egfsn090703_national_skills_bulletin_press_release.pdf. [Last accessed November 2012].

Forfás (2011). *National Skills Bulletin 2011.* Dublin: Forfás.

Fullan, M. (2001). Leading in a Culture of Change. New York: Jossey-Bass

Futurelab. *Enquiring Minds.* [Online]. Available at: http://www.enquiringminds.org.uk. [Last accessed May 2012].

Futurelab. (2009). 'Building Education for the Future'. *Vision: Looking at the future of Learning,* 6-8.

Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century.* New York: Farrar, Straus and Giroux.

Goh, C. T. (1997). *Shaping our future: Thinking Schools, Learning Nation.* [Online]. Available at: http://www.moe.gov.sg/media/speeches/1997/020697.htm. [Last accessed November 2012].

Government of Ireland. (1999). *Primary School Curriculum.* Dublin: Stationery Office.

Government of Ireland. (2008). *Building Ireland's Smart Economy, A Framework for Sustainable Economic Renewal.* Dublin: Stationery Office.

Government of Ireland. (2008). *Building Ireland's Smart Economy.* Dublin: Government of Ireland.

Government of Ireland. (2010). *Innovation Ireland, Report of the Innovation Taskforce.* Dublin: Government of Ireland.

Government of Ireland. (2011). *Programme for Government.* [Online]. Available at: http://per.gov.ie/wp-content/uploads/ProgrammeforGovernmentFinal.pdf. [Last accessed November 2012].

Government of Ireland (2012). *2012 Action Plan for Jobs.* Dublin: Government of Ireland.

Green, H. and Hannon, C. (2007). *Their Space Education for a digital generation.* London: Demos.

Gunderson, S., Jones, R., & Scanland, K. (2004). *The jobs revolution: Changing how America works.* Copywriters Inc., Chicago

Hagel III, J., Seely Brown, J. and Davision, L. (2010). *The Power of Pull: How Small Moves, Smartly Made, Can Set Big Things in Motion.* New York, NY: Basic Books.

Hall, G. and Hord, S. (1987). *Change in Schools: Facilitating the Process.* State University of York Press, Albany, NY.

Hargreaves, A., & Shirley, D., (2009). *The Fourth Way: The Inspiring Future for Educational Change.* Corwin Press. California

Havelock, R. and Zlotolow, S. (1995). *The Change Agent's Guide* (2nd ed.). Educational Technology Publications, Englewood Cliffs, NJ.

Hean, T. C. (2001, October 23). Leading Innovation in Education, *Speech given at the LEP Graduation Ceremony at Grand Copthorne Waterfront Hotel.* Singapore.

Hyland, Á. (2011). Entry to Higher Education in Ireland in the 21st Century Discussion Paper for the NCCA, *HEA Seminar.* Dublin.

Hylén, J. (2010). 'Can digital learning resources spur innovation?'. In OECD (Ed.), *Inspired by Technology, Driven by Pedagogy. A Systemic Approach to Technology-based School Innovations* (pp. 45-64). Paris, France: OECD Publishing.

International Society for Technology in Education (2007). *The national educational technology standards and performance indicators for students.* Eugene, OR: ISTE.

Irish Independent. (March 28th 2013). *Class of 2016 will be first to benefit from 'less stressful' points race.* [Online]. Available at: http://www.independent.ie/lifestyle/education/class-of-2016-will-be-first-to-benefit-from-less-stressful-points-race-29159890.html. [Last accessed April 30 2013].

Johannessen, O. and Pedró, F. (2010). 'Lessons learnt and policy implications '. In OECD (Ed.), *Inspired by Technology, Driven by Pedagogy: A Systemic Approach to Technology-Based School Innovations.* Paris, France: OECD.

Jones, A. (2004). *A review of the research literature on barriers to the uptake of ICT by teachers.* [Online]. Available at:
http://dera.ioe.ac.uk/1603/1/becta_2004_barrierstouptake_litrev.pdf.
[Last accessed November 2012].

Jukes, L. and McCain, T. (2002, June 18). *Living on the future edge:* The InfoSavy Group and Cyster.

Kang, N. and Hong, M. (2008). 'Achieving excellence in teacher workforce and equity in learning opportunities in South Korea'. *Educational Researcher,* 37 (4), 200-207.

Karmarkar, U. S. and Apte, U. M. (March 2007). 'Operations Management in Information Economy: Information Products, Processes and Chains'. *Journal of Operations Management,* 25 (2), 438-453.

Keenan, B. (2009). *We've never had it so bad,* **ESRI** *warns.* [Online]. Available at: http://www.independent.ie/national-news/weve-never-had-it-so-bad-esri-warns-1722550.html. [Last accessed May 2012].

Kennedy, J. (2009a). *More than 5,000 FIT graduates now in full-time employment.* [Online]. Available at: http://www.siliconrepublic.com/news/article/14439/business/more-than-5-000-fit-graduates-now-in-full-time-employment. [Last accessed May 2012].

Kennedy, J. (2009b). *Talent & Education.* [Online]. Available at:
http://www.siliconrepublic.com/news/article/14267. [Last accessed May 2012].

Kleiman, G. M. (2004). *Does Technology Combined with Inquiry-Based Lessons Increase Students' Learning?* [Online]. Available at:
http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED485616.
[Last accessed February 2012].

Kozma, R. B. (Ed.). (2003). *Technology, innovation, and educational change: A global perspective.* Eugene, OR: International Society for Technology in Education.

Kozma, R. B. (2005). *ICT, Education Reform, and Economic Growth* (White Paper): Intel.

Langworthy, M., Shear, L. and Means, B. (2010). 'The Third Lever: Innovative Teaching and Learning Research'. In OECD (Ed.), *Inspired by Technology, Driven by Pedagogy: A Systematic Approach to Technology-based School Innovations:* OECD Publishing.

Laurillard, D. and Masterman, E. (2010). 'TPD as Online Collaborative Learning for Innovation in Teaching'. In J. O. Lindberg and A. D. Olofsson (Eds), *Online Learning Communities and Teacher Professional Development: Methods for Improved Education Delivery* (pp. 230-246). Hershey, PA: Information Science Reference.

Laurillard, D. (2012). *Teaching as a Design Science. Building Pedagogical Patters for Learning and Technology.* New York and London: Routledge.

Leland, C. H. and Kasten, W. C. (2002). 'Literacy Education for the 21st Century: It's time to close the factory '. *Reading & Writing Quarterly,* 18, 5–15.

Levy, F. and Murnane, R. J. (2005). *How Computerised Work and Globalisation Shape Human Skills Demand*. Cambridge, MA: Industrial Performance Centre, MIT.

Loong, H. (2009). *Prime Minister Lee Hsien Loong's National Day Rally Speech 2009 on 16 August.* [Online]. Available at: http://www.pmo.gov.sg/content/pmosite/mediacentre/speechesninterviews/primeminister/2009/August/national_day_rallyspeech2009part4shapingsingaporetogether.html. [Last accessed November 2012].

Lyman, P. and Varian, H. R. (2003). *How Much Information? 2003.* [Online]. Available at: http://www2.sims.berkeley.edu/research/projects/how-much-info-2003. [Last accessed November 2012].

Martin, F., Butler, D. and Gleason, W. (2000). *Design, story-telling, and robots in Irish primary education.* Paper presented at the IEEE Systems, Man, and Machine Conference. Nashville, TN.

Marshall, K. (2012). E-portfolios - A discussion paper. Dublin: NCCA.

Mathews, J. (2009, January 5). 'The Rush for '21st Century Skills', New Buzz Phrase Draws Mixed Interpretations From Educators'. *Washington Post*

McGinn, A. (2007). 'Senior High School Education in the 21st Century'. *The Educational Forum,* 71 (4), 331 - 344.

Metiri Group. (2003). enGauge 21st century skills for 21st century learners. [Online]. Available at: http://pict.sdsu.edu/engauge21st.pdf. [Last accessed September 2012].

Microsoft Partners in Learning. (2012). *Microsoft Partners in Learning School Program.* [Online]. Available at: http://www.pil-network.com/pd/school. [Last accessed November 2012].

Ministerial Council on Education Employment Training and Youth Affairs (MCEETYA). (1999). National Goals for Schooling in the 21st Century. Melbourne: Curriculum Corporation.

Ministerial Council on Education Employment Training and Youth Affairs (MCEETYA) (2000). *Learning in an Online World: The School Education Action Plan for the Information Economy.* Adelaide: Education Network Australia.

Ministerial Council on Education Employment Training and Youth Affairs (MCEETYA) (2005). *Contemporary Learning: Learning in an Online World.* Melbourne: Curriculum Corporation.

Ministerial Council on Education Employment Training and Youth Affairs (MCEETYA) (2008). *Melbourne Declaration on Educational Goals for Young Australians.* Melbourne: Ministerial Council on Education Employment Training and Youth Affairs

Mishra, P. & Kereluik, K. (2011). What 21st Century Learning? A review and a synthesis. In Proceedings of Society for Information Technology & Teacher Education International Conference 2011 (pp. 3301-3312). Chesapeake, VA: AACE.

Mitra, S., Dangwal, R., Chatterjee, S., Jaha, S., Bisht, R., S. and Kapur, P. (2005). 'Acquisition of computing literacy on shared public computers: Children and the 'hole in the wall''. *Australian Journal of Educational Technology,* 21 (3), 407-426.

Mulkeen, A. (2003). 'What can Policy Makers do to encourage the Integration of Information and Communication Technology? Evidence from the Irish School System'. *Technology, Pedagogy & Education,* 12 (2), 277-294.

National Center on Education and the Economy. (2007). *Tough Choices or Tough Times: The Report of the new Commission on the Skills of the American Workforce.* [Online]. Available at: http://www.skillscommission.org/wpcontent/uploads/2010/05/ToughChoices_EXECSUM.pdf. [Last accessed November 2012].

National Competitiveness Council (NCC). (2009). *We cannot afford a defeatist attitude about our future prospects: Ireland must focus on the policies which improve competitiveness.* [Online]. Available at: http://www.competitiveness.ie/newsevents/news/title,2734,en.php. [Last accessed November 2012].

National Council for Curriculum and Assessment (NCCA) (2002a). *Developing Senior Cycle Education: Consultative papers on issues and options.* Dublin: NCCA.

National Council for Curriculum and Assessment (NCCA) (2002b). *Developing Senior Cycle Education: Directions for Development.* Dublin: NCCA.

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

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

National Council for Curriculum and Assessment (NCCA). (2009a). *Leading and Supporting Change in Schools: A Discussion Paper.* Dublin: NCCA
Available at: http://www.ncca.biz/Aistear/pdfs/Guidelines_ENG/Guidelines_ENG.pdf. [Last accessed November 2012].

National Council for Curriculum and Assessment (NCCA). (2009b). *Aistear: The Early Childhood Curriculum Framework. Guidelines for Good Practice.* Dublin: NCCA
Available at: http://www.ncca.biz/Aistear/pdfs/Guidelines_ENG/Guidelines_ENG.pdf. [Last accessed November 2012].

National Council for Curriculum and Assessment NCCA. (2010). *Innovation and Identity: Ideas for a new Junior Cycle.* [Online]. Available at: http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Junior_Cycle/Junior_cycle_developments/Documentation/Innovation_and_Identity_Ideas_for_a_new_junior_cycle.pdf. [Last accessed June 2012].

National Council for Curriculum and Assessment (NCCA) (2011a). *Towards a Framework for Junior Cycle: Innovation and Identity.* Dublin: NCCA.

National Council for Curriculum and Assessment (NCCA). (November 2011b). *Minister Quinn backs National Council for Curriculum and Assessment (NCCA) proposals for Junior Cycle reform.* [Online]. Available at: http://www.ncca.ie/en/News_Press/Press_releases/November_3rd_2011_Press_release_Minister_Quinn.pdf. [Last accessed November 2012].

NCREL & Metiri Group. (2003). *enGauge®21st Century Skills: Literacy in the Digital Age.* Los Angeles, CA.

Ng, E. H. (2008a). *Opening Address at the International Conference on Teaching and Learning with Technology (iCTLT).* [Online]. Available at:
http://www.moe.gov.sg/media/speeches/2008/08/05/opening-address-by-dr-ng-eng-h-1.php. [Last accessed November 2012].

Ng, E. H. (2008b). 'Educational reform in Singapore: from quantity to quality'. *Educational Research for Policy and Practice,* 7 (1), 5-15.

NYC iSchool. Available at:
http://schools.nyc.gov/ChoicesEnrollment/High/Directory/school/?sid=3528.
[Last accessed May 2012].

O'Leary, R. and O' Mahony, J. (Eds) (2010). *ICTs in the Primary School: Teaching & Learning for the 21st Century.* Dublin: Dublin West Education Centre.

OECD. (2005a). *The Definition and Selection of Key Competencies.* [Online]. Available at: http://www.oecd.org/document/17/0,3343,en_2649_39263238_2669073_1_1_1_1,00.html. [Last accessed May 2012].

OECD (2005b). *Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us.* Paris, France: OECD.

Papert, S. and Harel, I. (1991). *Situating Constructionism.* [Online]. Available at: http://www.papert.org/articles/SituatingConstructionism.html. [Last accessed November 2012].

Partnership for 21st Century Skills. (2007). *The Intellectual and Policy Foundations of the 21st Century Skills Framework.* [Online]. Available at:
http://youngspirit.org/docs/21stcentury.pdf. [Last accessed November 2012].

Partnership for 21st Century Skills. (2008). *21st Century Skills, Education and Competitiveness: A Resource and Policy Guide.* Washington, DC: Partnership for 21st Skills.

Pedró, F. (2010). 'The need for a systemic approach to technology-based school innovations'. In OECD (Ed.), *Inspired by Technology, Driven by Pedagogy. A Systemic Approach to Technology-based School Innovations* (pp. 13-20). Paris, France: OECD Publishing.

Project Maths. (2012). *Project Maths, Learning and Teaching for the 21st Century.* [Online]. Available at: http://www.projectmaths.ie. [Last accessed November 2012].

Project Tomorrow. (2009). *Learning in the 21st Century: Parents' Perspectives, Parents' Priorities.* [Online]. Available at:
http://www.tomorrow.org/speakup/learning21Report_2009_Parents.html. [Last accessed May 2012].

Quinn, R. (2012). *Speech on the launch of the Junior Cycle Framework.* Paper presented at the Launch of the Junior Cycle Framework. Department of Education and Science: Dublin.

RAND Corporation. (2004). *The Future at Work—Trends and Implications.* [Online]. Available at: http://www.jpgassoc.com/PDF/client-future-at-work.pdf. [Last accessed May 2012].

Rogers, E. M. (2003). *Diffusions of Innovations, 5th Edition.* New York, NY: Free Press.

Ryan, J. (2009). *The Next Leap: A Competitive Ireland in the Digital Era.* Dublin: The Institute of International and European Affairs.

Sahlberg, P. (2009). 'Educational Change in Finland'. In A. Hargreaves, M. Fullan, A. Lierberman and D. Hopkins (Eds), *Second International Handbook of Educational Change* (pp. 1-28). Dordrecht, Netherlands: : Kluwer Academic Publishers.

Seely Brown, John (2006). New Learning Environments for the 21st Century: Exploring the edge. The Magazine of Higher Learning Issue: 38 (5), September-October 2006.

Somekh, B. (2007). *Pedagogy and Learning with ICT: Researching the art of innovation.* London: Routledge.

State Examinations Commission (SEC) (2006). *Junior Certificate Examination 2006 -* Mathematics: SEC.

Sweeney, J. (2009). Creating an Inclusive Smart Economy, FIT conference

Tapscott, D. (2008). *Grown up digital. How the net generation is changing your world.* New York: McGraw Hill.

Thornhill, D. (2009). The role of education in rebuilding the economy - Only the best will be good enough, *MacGill Summer School*.

Toffler, A. (1970). *Future Shock*. New York: Bantam Books.

Tsuneyoshi, R. (2005). 'Teaching for "thinking" in four nations: Singapore, China, the United States, and Japan'. In M. Kaneko (Ed.), *Core academic competences: Policy issues and educational reform*. Tokyo: Centre for Research of Core Academic Competences.

US Congress (2011). *Economic Report of the President*. Washington, DC: The Annual Report of the Council of Economic Advisors.

Wallis, C. (2006). *How to Bring Our Schools Out of the 20th Century.* [Online]. Available at: http://www.time.com/time/magazine/article/0,9171,1568480,00.html. [Last accessed November 2012].

Wagner, T. (2008). *The Global Achievement Gap: Why Even Our Best Schools Don't Teach the New Survival Skills our Children Need - and what can we do about it?* New York, NY: Basic Books.

Wesch, M. (2007). *A Vision of Students Today.* [Online]. Available at: http://www.youtube.com/watch?v=dGCJ46vyR9o. [Last accessed November 2012].

Westbury, I., Hansen, S.-E., Kansanen, P. and Bjorkvist, O. (2005). 'Teacher education for research-based practice in expanded roles: Finland's experience'. *Scandinavian Journal of Educational Research,* 49 (5), 475-485.

Zhao, Y., Pugh, K., Sheldon, S. and Byers. J. (2002). Conditions for Technology Innovations, Teachers College Record, 104 (3), pp. 482-515

Zhao, Y. (2009). Catching up or leading the way. Alexandria, VA: ASCD.

Appendix 1

A note on the meaning and use of the term 21st century skills

Many organisations and research papers refer to the '21st century skills' that students need to master if they are to function effectively in society today and in the medium term. Although the term is used prolifically, it is often unclear what is actually meant by '21st century skills'. "In some sense, the whole idea of 21st century skills becomes an empty signifier, a term that we all think we understand and yet are hard-pressed to clearly define" (Mishra & Kereluik, 2011, p. 3301). Undeniably, the term '21st century skills' is a contested term and perhaps is a misnomer with some pointing out (Dede, 2007) that at best we can only try to predict the capabilities that people will require in the short term. Others, such as the OECD (2005), the EU Commission (2008) and the National Council for Curriculum and Assessment (NCCA, 2008a), use terms such as 'Key Skills' and 'Key Competences' to describe the skills they identify as necessary for living in the 21st Century. However, there is a strong overlap between these terms. For example, 'Key Skills' are defined as information processing, critical and creative thinking, working with others, communicating and being personally effective (NCCA, 2008a, p. 10). The EU classify their "Key Competences" (ETA, 2010) as Communication in mother tongue; Communication in a foreign language; Mathematical literacy, science and technology; Digital competence; Learning to learn; Interpersonal, intercultural, social and civic competences; Sense of innovation and entrepreneurship and Cultural awareness and expression. They define competences as a combination of knowledge, skills and attitudes appropriate to a particular context. 'Twenty-first century skills' (21st Century Skills) on the other hand, are defined as including creativity, innovation, critical thinking, problem-solving, communication and collaboration (Matthews, 2009). Whether the term used is 'key competences' or 'skills', it is commonly acknowledged that all individuals will need them for personal fulfilment and development, active citizenship, social inclusion, and employability. In this paper we are using the term '21st century skills' as it tends to be the term that is more commonly used globally.

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Michael is a founding partner with H2 since 2002. Michael currently holds the post of Director of Learning for The Digital Hub Development Agency (DHDA). The DHDA implements a range of education and training programmes under the umbrella of The Digital Hub Learning Initiative. The Learning Initiative focuses on the learning and training needs of the local community, schools and the digital media sector. The programme is implementing a range of showcase programmes including Future Creators and a Schools Broadband Exemplar initiative. These initiatives are designed to inform good practice in schools and ultimately policy on the use of broadband in schools and the design and implementation of after-school programmes using digital technologies. Previously he worked with the Department of Education to develop their first ICT in schools policy, Schools IT2000, and held the post of National Co-ordinator for Interactive Software in the Curriculum from 1998 to 2002 within the NCTE. Subsequently he worked with the World Bank in Turkey between 2002 and 2006 on ICT in School issues that included teacher professional development, ICT policy development and the effective use of digital technologies in schools.

Michael has long been associated with teaching and research in the field of digital technology. In his role as an academic consultant he led the implementation of Hibernia College's Masters in Arts in Teaching and Learning (MATL) as course director from 2010 to 2012. He has also worked on post-graduate course design for Trinity College and the University of Limerick. More recently he has been working with HE faculty to transform their practice when using digital technologies and much of this work is based on this doctoral research within the Institute of Education in London. Here his research has focused on articulating a signature pedagogy for online tutorials and assisting faculty enhance their practice with the goal of improving student learning experiences. He is a board member of iScoil, Ireland's first online school and Chairperson of D8CEC, an adult community education centre located in Dublin 8.

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Deirdre Butler's passion in life is exploring what being digital in learning can mean. She is interested in ways that using digital technologies could revolutionise learning by challenging us to examine how we learn and to question our assumptions about "traditional" models of schooling.

Deirdre is a senior lecturer in Education at St. Patrick's College, Ireland (www.spd.dcu.ie) with responsibility for designing and co-ordinating learning programs for undergraduate and postgraduate students using a broad range of digital technologies to enable them to understand what being digital in learning can be. She has extensive experience in the theory and practice of digital learning, as well the design and development of sustainable, scalable models of teacher professional development. She has also designed, developed and managed a range of projects and school based initiatives which focus on the creative use of digital technologies (e.g. Empowering Minds, EduWear, TeachNet).

Deirdre was Chair of the international advisory board for the second phase of Microsoft's Partners in Learning initiative (MS-PIL 2008-2013) and is a member of the worldwide Teacher Education Initiative (TEI) Advisory Board. She is a key advisor to the Innovative Teaching & Learning ITL Research which is a multiyear global research program designed to investigate the factors that promote the transformation of teaching practices & the impact those changes have on students' learning outcomes across a broad range of country contexts. Finally, she is member of the Horizon K12 Advisory Board whose task is to manage the process of researching, discussing, and ultimately, selecting the topics for the annual Horizon Report: K-12 Edition which focuses on emerging technology and its applications to K-12 education.

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John has played a key role in the development of CPD programmes for principals and deputy principals around the issue of broadband provision in schools. He has worked closely with Microsoft Ireland in developing and implementing this programme through the education centre network during 2012-13. He is also centrally involved in a number of EU projects that are directly addressing issues such as new forms of student and teacher assessment in the 21st century.

John has considerable teacher professional development experience and is a member of the TeachNet Ireland management team designing and delivering cutting edge training for practising teachers on the use of ICT in Irish schools. John has worked on post-graduate course design for Trinity College, University of Limerick and Hibernia College. John is a qualified primary teacher and holds a B.Ed. from Trinity College. John holds an MBA from Dublin Business School.

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Dr. Kevin Marshall is a Head of Education, Microsoft Ireland. He has represented on a number of committees such as the teaching Council, the NCCA. He was Chair of IBEC's Education committee and represents IBEC, 2004-2008. Furthermore, he is a member of the Marion Institute of Education. He is also visiting research fellow at the Centre for Research in Information Technology (CRITE) located at Trinity College Dublin. Prior to working in Ireland, Kevin worked in Boston Public Schools in the Office of Research, Assessment and Evaluation and was responsible for the School-to-Work transition. He has a BA in Psychology from University College Dublin, a MSc in Industrial Psychology from the University of Hull and a PhD from Boston College.