'Wicked Problems' and the Work of the School

STEPHEN MURGATROYD

> *In times of change, learners inherit the Earth, while the learned find themselves*
> *beautifully equipped to deal with a world that no longer exists*

> *Eric Hoffer*

Introduction

Communities are challenged. They are challenged by changes in the climate, which will affect the quality and supply of water, the quality of the air, agricultural development and migration patterns (Lomberg, 2007; Monbiot, 2007). They are challenged by rapidly changing economic circumstances in which established industries are experiencing a great number of dislocations (Krugman, 2008). Shifts in the pattern and intensity of world trade have had an impact on skills and employment (Friedman, 2005, 2008). They are challenged by the emergence of new technologies and their impact on health systems, key industries and people's psycho-social world (Anderson, 2006; Tapscott & Williams, 2006). Communities are also challenged by new patterns of illness and disease which are leading to epidemics of childhood obesity, early onset diabetes and heart disease (Gard & Wright, 2005). These are substantial challenges and are occurring at an accelerated pace. They have psycho-social as well as communal and economic impacts. Many people seem to find the nature and speed of these developments stressful (Shumaker, Ockene, & Riekert, 2008) and others find that their coping mechanisms are challenged (Kher, 1997).

These challenges demand action on the part of individuals, communities, companies, non profits and government. Their response is varied in terms of intensity and effectiveness. Some governments have developed systematic and focused plans for action on climate change, agriculture, industry development and technology management, others have not. While governments may have plans, they depend entirely on supportive institutions and a creative class of people to execute these plans that does so in such a way as to build new communities of practice and interest (Docherty *et al.*, 2009; Florida, 2002). Companies are responding. Some are successful, others not. Non-profit organisations are pioneering social networks and ways of working across boundaries with people who may be otherwise disengaged. There is a firmament of activity involving fundamentally different ways of organising, working, creating, thinking, knowing and doing. In short, human capital is being viewed in new frameworks.

Our schools remain largely untouched by this revolution in organisational design, emergent technology, the globalisation of skills, social and knowledge networks, cloud based decisions and co-creation of ideas and understanding (Szabo, 2002; Papert, 1993). Many teachers still teach subjects in a way that resembles how this was done 25 years ago or more. The curriculum, rather than

being radically different from what it was before the widespread use of the Internet began in 1993–94, is basically similar with more items added, giving less time for creativity (Robinson, 2001). The fact that the speed of discovery is such that the quantity of available information doubles every 10 to 18 months (varying by discipline) and that much of what is taught in schools is, by definition, outdated seem not to matter. Teachers and schools are part of a command and control model of school systems which is outdated for knowledge intensive organisations. It is difficult to imagine a social organisational system which seems as immune to change as the school systems of Britain, the US and Canada. The knowledge-driven organisation which demands innovation and creativity on the part of all employees does not correspond to many aspects of school systems.

The new political epistemology moves us from truths that can be proven and verified or falsified to narratives that can be constructed. The narrative about schools and change is that they are at the forefront of change. The reality, which can be attested, is that they are not — they look, feel and are almost exactly as they were 25 years ago. Some technology has crept in, but is minimally used; new targets have been set, but are rarely met; and new assessment regimes have mushroomed, but are distractions from learning. School systems as organisations seem paralysed and are, according to Meyer and Zucker (1998), permanently failing organisations — they do not live up to the promise of schooling either for many of their students or for the communities in which they are embedded.

In this article, the focus is on innovation and design as responses to the challenges faced by communities. These terms are examined and defined and their implications for the nature of school systems, the practice of teaching and the focus for learning are analysed. Since innovation and design are skills and ways of working that can be taught, the article explores the implication of this fact for curriculum and the process of learning. Some specific examples of the ways in which school systems, schools, classrooms and learning can be harnessed in the service of community through design and innovation are provided, based on the principle of authentic learning tasks as the bedrock of educational activity. The article builds from current practice in a number of projects and activities and looks to a different focus for the work of the teacher and for the design of the school as an organisation.

The Driving Forces to which Schools are Responding

Four factors are currently influencing decision-makers in their desire to reform and improve schools. The first is the view that human capital needs of the 21st century — the so called 21st century skills — are different from those of the last century. These differences are usually presented in terms of the idea that all citizens are both producers and consumers (*prosumers*) and global connectivity, social networking, team skills and critical thinking are said to be sufficiently distinctive to require curriculum reform (Tapscott & McQueen, 1995; Partnership for Twenty First Century Skills, 2008). Others have suggested that these 21st century skills are less different than the work that many schools have been pursuing since Montessori and are mainly descriptors of excellent teaching practices, especially those involving critical thinking, creativity, and problem-solving. Nonetheless, 21st century skills are seen to be a human capital strategy that requires a different approach to the process of learning.

The critical voices suggest that a focus on process skills rather than on core competences implied by the 21st century skills movement is seriously flawed. They offer four basic criticisms: (a) that there is a forced separation between knowledge and skills; (b) that teachers are capable of working on complex problems beyond their cognitive abilities; (c) that experience is equivalent to practice; and (d) that communities and organisations in the 21st century need knowledge and skills that are very similar to those they have needed for the last 25 years (Willingham, 2009). Despite these concerns, many jurisdictions are making significant changes to the school curriculum requirements and are investing in teachers' professional development to better equip them for 21st century learning and teaching activities.

The second factor that is driving a demand for change in schools is the changing nature of the student body — the human capital that is an 'input' to the school system. Students beginning school in September 2010 will retire from the workforce between 2070 and 2080, if they enter it at all. Unlike their great grandfathers, most will occupy some 15–20 jobs and stay no more than five to seven years with a single employer. Work-life balance for many of this *iGen* (also known as the '*text generation*' or *Generation Z*) will be a bigger issue than pensions. They will expect their employer to practise strategic human resource policies which help their personal and professional development and will look on work as one source of satisfaction, but it will not be the centre of their lives. They will bring to their work remarkable technical skills, a strong entrepreneurial outlook, a deep-seated social consciousness (especially with respect to the environment), and, like every 'new' generation, a healthy dose of questioning and a desire for change. This generation will understand the power of social networks, cloud based computing and technology and will absorb such technologies to facilitate work and social transactions, change work practices and engage in global conversations (Palfrey, 2008; Tapscott, 2008). They will have these skills despite their school systems, which currently seem unable to engage these technologies in the pursuit of learning, knowledge and understanding. Indeed, many school systems are outlawing social networking technologies, seeing them (sometimes with good reason) as distractions. The *iGen* will also be quick to leverage the rapid emergence of machine and artificial intelligence as well as domestic and social robotics — they will 'get' change as a constant in a way that the current generation of leaders and managers still find difficult — and challenge current managerial assumptions about the nature and function of human capital. A particular strength of the *iGen* will be their ability to multitask, to network globally and to assimilate complex information and ideas from a range of sources. As the world becomes increasingly globalised (Stiglitz, 2006), this generation will progressively engage in what is known as the 'neurosphere' (Dulchinos, 2005) or 'singularity' (Kurzweil, 2005) — the integration of intelligent machines with human intelligence. Yet their schooling will not have prepared them for the challenge of such an integration, unless things change. As Sir Kenneth Robinson observes (Robinson, 2006), schools are in the process of preparing young people for jobs that do not yet exist which require skills we do not fully understand and will use technologies which are in the process of being invented. Yet they will behave as if the economic need for human capital had not changed since the turn of the 20th century. The *iGen* will also be familiar with some of the basic concepts of design. Many will own their web space, will be familiar with social networks and will have created a weblog (blog) which they will have customised or designed. They will also be increasingly aware of design as a

question of choices and deliberate decisions concerning the environment, technology, living spaces and clothing. They will have personalised their handheld digital device through a unique combination of applications, self design covers and add-on features. One teacher suggested that 'this is not simply a different generation, it is a different species', which has led some researchers to term the *iGen* as 'homo-zappiens' (Veen & Vrakking, 2006), reflecting not just different learning styles, but also a distinctive psychobiology. These homo-zappiens will provide the basis for human capital development in our communities and economies. Through their behaviour, they are already changing the way some industries work (Hayes & Malone, 2009).

The third factor leading many to suggest that schools need to change is technology. Alberta is not an untypical school jurisdiction. It has some 600,000 students and spends $6.3 billion (€4 billion) on compulsory schooling. Over the last decade it has spent $1.87 billion (€1.2 billion) on technology for schools, including investments in network infrastructure, a learning objects repository, video conference networks and lap top programmes. While some of these investments have been directly linked to specific change agendas — e.g. the Alberta Initiatives' for School Improvement (AISI) —, others have been generalised investments responding to a perceived need to make technology available. The impact of these investments appears marginal and they have certainly not led to any major change in how schools as organisations function across the jurisdiction.

But technology is changing quickly. The development of the semantic web, handheld and mobile devices increasingly used for learning and education and the emergence of robotics for learning and teaching create opportunities to change the processes whereby learning takes place and knowledge is used in discovery, innovation and the development of understanding. Jurisdictions are struggling to find a balance between teachers, technology and processes for effective learning.

The final force that drives change is the demand for accountability. Schools, like many public organisations, are being asked to demonstrate outcomes against targets and that they are efficient in managing resources. Standardised achievement testing, usually at key stages of the students' progress through school, is used to assess the veracity of schools as organisations and the effectiveness of teaching. These 'high stakes' tests are used to rank schools, review the performance of pupils in particular areas and compare jurisdictions. Alberta, for example, is proud that its scores on such tests are the highest in Canada and rank just behind Finland on the PISA international comparisons. Whilst there is a backlash against such testing, others see accountability as a key pillar in ensuring the performance of schools as organisations and use the data to counter the argument that schools do not meet expectations — in fact, in many cases, they outperform them.

All these current forces of change are to be seen as additional to the normal forces that affect school systems — the demand for better quality, for schools to be responsive to social and health needs of communities, and that they should be key social instruments for the ambitions of interest and pressure groups.

In making decisions about what to do about schools, Ministers and senior officials have another imperative: to build jurisdictional advantage. Schools are seen as major instruments in building the competitive advantage of nations (Porter, 1990) in that they develop the core human capital skills that a jurisdiction needs to compete against others in the globalised knowledge-based economy.

Decisions on schools are inextricably linked to the view of the human capital requirements of a jurisdiction having to compete with other jurisdictions for jobs, firms and opportunities.

The Response of School Systems to the Challenge to Change

When faced with this array of challenges, what do jurisdictions do? While the response to this question is complex, there are three distinctive patterns. The first is to set targets and focus on accountability — threatening weak and poorly performing schools with a 'turn-around' by managers known for their skills in changing 'failing' schools into successful schools. Britain seems to be pursuing this strategy, insisting on performance management regimes, publishing league tables, using inspection regimes and setting targets. We could call this *the 'factory model' of schooling*, since it stresses command and control and targets.

The second pattern is to load the curriculum with more and more features and components so that students have more skills and competence inputs and choices. Alberta and many other North American jurisdictions are pursuing this strategy. Key to the strategy is the involvement of teachers in the development of a jurisdictional curriculum, working in partnership with universities, colleges and technical institutions. The curriculum is then revised on a rolling 3- to 5-year cycle and materials which relate to it are developed, acquired or accessed. Typical Grade 7 science students will have over 200 objectives to achieve in each subject they study — Grade 7 science in Alberta, for example, has some 265 objectives. Across all subjects, students in Grade 7 will be expected to successfully master over 1,350 outcomes. They are tested periodically (Grades 3, 7, 9 and 11) as to their performance and schools are supported in their efforts to continually improve performance. Testing is intended as an improvement strategy for schools and is a way of ensuring students' compliance with the curriculum. In Alberta, some 30% of school students do not complete high school and some 15% will not complete their college or university education. We can call this *the 'load-up' strategy*.

The third pattern is to rethink the work of schools around the simple concept: 't*each less and learn more'*. The idea is to encourage and enable the development of innovation and creativity skills through problem-solving and greater student engagement. While subjects are taught in the framework of broad system-wide curriculum objectives, teachers have a considerable degree of freedom to achieve learning outcomes and expand the learners' horizons. Using starting points such as Howard Gardiner's *Five Minds of the Future*, these schools see education as encouraging exploration, creativity and curiosity and instilling values. Singapore has embraced it, seeing the knowledge economy and the development of the creative class as critical to its economic future. We can call this response the *innovation strategy*.

Such a classification clearly oversimplifies the complex response of school systems to challenge, threat, opportunity and change. Many change strategies are a combination of these three basic responses. Also, within any jurisdiction there will be schools pursuing each of these strategies. However, these three frameworks provide a useful starting point to explore the strategic intent of change leaders with respect to school systems. For the balance of this article, the focus is on innovation and creativity as the basis for the work of schools and the development of human capital for jurisdictional advantage.

'Innovation' and 'Design'

There are many definitions of innovation. Sahlberg (2009), for example, defines it as 'the extraction of economic and social value from knowledge', putting ideas to work in such a way as to produce either economic or social returns (or both), since innovation provides a solution to problems which exist or creates an opportunity not yet imagined. This definition emphasises ideas in use, not just to ideation. Sahlberg also points out, like others, that innovation is a non-linear process requiring team effort and great self-organisation. Effective innovation is focused, iterative and cumulative. Few really understand the innovation process in its complexity, but nonetheless there are many innovators.

The term 'design' is defined in a similar way. It is, according to Margolis and Buchanan (1995) 'the human power to conceive, plan, and realize products that serve human beings in the accomplishment of any individual or collective purpose'. This seems broader than the definition of innovation and embraces more specific models of design as a process in fields such as culinary arts, web design, video game design and simulation, interior design, architecture, marketing, sustainability, retail, packaging, set design in theatre, film, etc. Many see design as moving beyond 'innovation', which is a stage in the design process, and apply it to a wide array of challenges and opportunities, including those challenges which face communities (Margolis & Buchanan, 1995). More importantly, design provides a common core process and set of insights which inform a variety of communities of practice (Hara, 2008).

Underlying the design process is 'the management of constraints' (Dini, 2005). Designers must meet the needs and expectations of clients or commissioning communities, but must also work within real constraints of resources, the laws of physics and biology, mathematics and science. They need to be both well informed and 'street smart'. Design is both a rigorous and a creative process. It challenges individuals and teams to solve real world problems and, by doing so, create something new and inspiring, something that touches both heart and mind. These are key requirements for workers in the 21st century — an ability to use a design process to solve the next challenge that confronts them.

Much of the writing on innovation does not capture this same character of experience. Design is broader yet more specific and has a substantial discipline of practice associated with it. Innovation focuses instead on the complex process of creation and the range of different skills required to take an idea from conception to action — but is disconnected in many ways from the work of teachers working within one or more of the strategies at play in their jurisdiction. Design, however, is something that can be taught and used in any school and for any subject. It is a means for turning innovative ideas into practice.

Much of the writing about innovation confuses this work with research and development activities which, while related, are very different (Bartzokas, 2000; Mytelka & Smith, 2001). While there is some focus on innovation as a process, most of it is linked to innovation developments in universities and to commercialisation activities. While this is important, most companies do not innovate in this same way, relying more on the adaptation of practice or adopting practices which work in other firms, sectors or jurisdictions. One estimate is that some 95% of innovation in firms consist in adopting/adapting (Cornford & Murgatroyd, 2006; Murgatroyd, 2006). Where innovation is the appropriate language of description is

when developments occur which disrupt and fundamentally change the nature of an industry or activity in the community. Disruptive innovation is substantive, destructive and creative at the same time. For example, Internet has revolutionised the music industry, travel, banking and is beginning to do the same for the film industry. Established ways of working are being destroyed and new ways have been created. Robotics has revolutionised manufacturing and will shortly do the same for health care and care of the elderly. Genomics (and related 'omics'), together with stem cell research and nanotechnology, will revolutionise medicine, the food supply and many other industries (Steffen, 2006). Here, these innovative technologies so fundamentally change practice that existing ways of working are replaced by new ones. These developments are truly innovative. They configure human capital in different ways to produce different results.

Teaching Innovation and Design

> *The best way to predict the future is to design it — Buckminster Fuller*

Given that there are challenges which communities face and design processes which enable communities to respond creatively and imaginatively, but within constraints — a process which also encourages and enables innovation — what can schools teach to develop the required skills and competences for design and innovation to be effective?

First, they can see design as a process that is at the heart of the experience of learning and core to all curriculum domains — a core skill and competence which students need to be successful in the 21st century. This may seem like a bold claim, but pause: design involves both developing a 'big idea' that is appropriate for the challenge at hand, 'landing' it into a project and then executing it, adapting to circumstances and constraints en route, and satisfying the authentic customer or client for the challenge. Design is a life skill.

Second, they can find ways to harness the power of learning with a focus on design so as to foster problem-focused solution finding linked to real world challenges and authentic audiences. They can challenge learners to solve real world problems that have real people wanting real solutions and use this learning to secure authentic knowledge, engaged learners, coverage of the skills and knowledge needed by the curriculum at that stage of their development and enable learners to see the value of their learning through the implementation of design. Problem-based learning has a long history and is widely used, especially in primary education. What is needed is the extension of this approach to learning to include those at colleges and universities. Access to information, social networks and global mentoring supports enables this in this century in a way that was hitherto impossible.

Third, they can connect the principles of design to the study of different disciplines (philosophy, mathematics, biology, physics, history, social studies, language arts, etc). Rethinking curriculum in terms of both focus and process is essential to rethink schools and develop 21st century learning that is appropriate for the development of the human capital assets our communities need to solve 'wicked problems'.

The teaching of design has three components: thinking, making, and doing. To teach critical thinking and disciplined understanding, students must have roots in the basic disciplines (science, mathematics, language arts, social studies, fundamentals of technology, philosophy) and be able to synthesise these in an effective

way. Extensive and in depth knowledge, at least during compulsory schooling, is less important than an in depth understanding of the methodologies of these disciplines, the core knowledge they require and an understanding of contemporary practices which make use of these disciplines (Gardner, 2006).

Critical thinking skills, according to Facione (2009), are a complex array of ways of thinking which include analysis, inference, explanation, evaluation, and interpretation, all conducted in a self-regulatory fashion. While these analytic and conceptualisation skills look abstract when presented here, they are in fact the bedrock of all disciplines. They can be taught, if approached systematically, through a variety of devices including a focus on science, mathematics, philosophy social studies, language arts and technology. However, critical thinking is not just a set of skills, it is also a *disposition*. Characteristics of a disposition to critical thinking, again according to Facione (2009), are seen in the following attributes:

- inquisitiveness with regard to a wide range of issues,
- concern to become and remain well-informed,
- alertness to opportunities to use critical thinking,
- trust in the processes of reasoned inquiry,
- self-confidence in one's abilities to reason,
- open-mindedness regarding divergent world views,
- flexibility in considering alternatives and opinions
- understanding of the opinions of other people,
- fair-mindedness in appraising reasoning,
- honesty in facing one's own biases, prejudices, stereotypes, or egocentric tendencies,
- prudence in suspending, making or altering judgements,
- willingness to reconsider and revise views where honest reflection suggests that change is warranted.

In terms of the 'making' component of critical thinking, students need to be challenged to produce tangible products, services or activities which are valued by others. Rather than simply producing essays, book reports, research posters for science — all of which have value — they should be required to work with community organisations on design challenges which will make a difference. For example, when a team of young students was asked to design a robot that would patrol levies and dams looking for cracks, these dispositions together with strong and effective teamwork and partnership with a group of adult mentors were fully revealed. The 'making' was not just for class, it represented an opportunity to make a social contribution. This is also the case with other projects of the Galileo Educational Network which has worked since 1998 with 50,000 teachers worldwide to develop meaningful learning challenges which not only develop skills, but enhance the disposition to see learning as a response to social challenges or opportunities.

'Doing' as a step in critical thinking and the design process represent the iterative process of offering a solution, testing it and then revising it in the light of evidence of performance, the resource implications of the solution and the management of constraints and the feedback from the 'customer' or client, whether it is the teacher or others. It is important that as many 'real world' tests of the design process with different customer groups should occur across the students' school experience, since this will help them to understand the process of design.

Innovation illiteracy, as assessed by a variety of instruments, is now seen as a major challenge in economies seeking to secure jurisdictional advantage (Asheim, Boschma, & Cooke, 2007) and can be combated in part by the development of a disposition to critical thinking coupled with that of critical thinking skills, but also by the systematic pursuit of a design and creativity agenda across the curriculum (Jeffrey & Woods, 2009; Sawyer, 2006). There are a great many resources to support this work, with several programmes to develop the required skills for teachers now emerging (e.g. Buffalo State University offers graduate programmes related to this work). Overcoming innovation illiteracy and promoting creativity, design and innovation should be seen as critical to the 21st century human capital agenda.

Using 'Wicked Problems' as the Focus for Learning

One way to teach critical thinking, design, innovation and creativity is to use authentic learning tasks or inquiry-based learning as the core activity of schools, replacing subject-based teaching by learning activities that require disciplined knowledge, synthesis, critical thinking and design so that the learners' response is not only appropriate, but based on the rigorous and disciplined development of knowledge and skills and a formalised rubric (Clifford & Marinucci, 2008).

The core idea here is that real problems faced by communities, groups or individuals become the focal point through which learning occurs. While some of these problems may be simple — how do we know what CO_2 emissions emanate from the school and what can we do to reduce them — , others may be much more complex and challenging. They may in fact be 'wicked' problems. The term 'wicked problems' is used extensively in design and software development (Churchman, 1967). 'Wicked problems' have certain common characteristics according to Rittel and Melvin (1972). According to Margolis & Buchanan (1995):

1. Wicked problems have no definitive formulation, but every formulation of a wicked problem conforms to the formulation of a solution.
2. Wicked problems have no stopping rules.
3. Solutions to wicked problems cannot be true or false, only good or bad.
4. In solving wicked problems, there is no exhaustive list of admissible operations or solutions.
5. For every wicked problem, there is always more than one possible explanation, with explanations depending on the *Weltanschauung* of the designer.
6. Every wicked problem is a symptom of a higher level (more wicked) problem.
7. No formulation and solution of a wicked problem have a definitive test.
8. Solving a wicked problem is a 'one shot' operation, with no room for trial and error.
9. Every wicked problem is unique.
10. Every wicked problem solver has no right to be wrong — they are fully accountable and responsible for their actions.

Such wicked problems, when based on genuine community or organisational needs, require learners to develop skills and competences and also responsibility dispositions which should be characteristic of 21st century learning and teaching.

When the author of this article was training as a teacher he was taught 'never to ask a question to which you do not know the answer'.

Many schools have already chosen to pursue problem-based learning and wicked problems for much of their learning activity. They understand the power of real life problems as tools for carrying a range of curriculum and teaching options — the more 'wicked' the problem the more learning that is possible. The three short examples selected below (see Table I) illustrate the way in which a design-focused process which uses critical thinking, innovation and creativity as the core methodologies for inquiry based learning could focus on meaningful community challenges and engage young people as part of the solution to these challenges. Each of these requires student engagement, authenticity, rigour (as evidenced by both formative and summative assessment), engagement beyond the school, active exploration using appropriate technologies, a strong and meaningful connection to others (especially adults) with appropriate expertise, teamwork and elaborated communication, as well as an element of fun and a great deal of imagination.

These examples are intended to illustrate the power of authentic wicked problems as a means for not only ensuring that system-wide curriculum expectations are met, but that, in doing so, students experience the fact that their knowledge and understanding can make a difference to a community, i.e. rather than school being a preparation for life, it is a place where life is experienced to the full. Students develop a passion for learning based on rigour, depth of understanding and making a contribution. They also come to understand that action is not just what other people do, it is something each of us has a responsibility for. In this way, a focus on authentic wicked problems entails innovation.

This work has often been misunderstood. The common misconception is that teachers abrogate their responsibilities for learning outcomes, since they shift from a role of instructor to a role of coach, guide and mentor (Kirschner, 2006). Yet, as the evidence makes clear (Jardine *et al.*, 2002; Jardine, Clifford, & Friesen, 2006) teachers who engage their students in a process of discovery which is rooted in the need to master the core skills requirements of a jurisdiction (as opposed to the contents of a text book and the myriad of objectives which have found their way into a third party imposed curriculum) and, in doing so, understand the relevance of this learning for real world situations achieve high level learning outcomes in both cognitive and emotional domains — emotional intelligence grows alongside knowledge and understanding (Hmelo-Silver & Chinn, 2007).

Another misconception of the inquiry-based approach is that it will be too difficult for students to chart their own course of learning, that they need the rigidity of a set verbatim curriculum, or that they are too intellectually immature for it to be effective. Responding to this, Clifford & Marinucci (2008) state:

> Inquiry demands an orientation to what matters . . . Less rigorous approaches to inquiry, which privilege the children's questions and interests simply because they *are* the children's, can quickly degenerate into sentimental practice that shies away from thorny conversations about whether mistakes are being made or misconceptions overlooked . . . Students trained in the habits of inquiry have much less fear that making a mistake revels their own personal ignorance and are much more interested in the quality of their thinking, part of which involves a commitment to rigor on behalf of the topic. Uncovering error becomes a way to learn.

TABLE I. Examples of Wicked Problems

Challenge	Focus for the Inquiry	Sample of Skills and Knowledge Required
Analysing the Incidence of Childhood Obesity and Early Onset Diabetes of Family Members	• Understanding the links between food, exercise, smoking, social behaviour and health • Documenting the incidence of various stages of obesity amongst/diabetes in the age cohort in the community • Partnering with other schools globally to compare and contrast obesity and diabetes amongst the age cohort	• Some basic biology, nutrition, socio-economic geography, demographics, epidemiology, social history, comparative medical epidemiology • Range of measurement, recording and survey skills • Emotional intelligence and social sensitivity • Language arts and social studies (including historical approach to development of epidemics)
Advising the Community on Appropriate Adaptive Responses to Climate Change	• Understanding the debate about climate change as a scientific, social and political challenge • Understanding regional scenarios for climate and weather systems over the lifetime of the student in their community • Looking at the impact of cooling and warming scenarios on water supplies, air quality, agriculture, health, biodiversity, power consumption and generation, migration patterns etc from a regional/community perspective • Analysing adaptation options and weighting them • Engaging others world-wide in this work	• Understanding weather patterns and climate as different but related things • Getting beyond the rhetoric and alarmism and looking at evidence and the implications of evidence — generating action plans based on scenarios • Understanding some basic physics, climatology, plant and animal biology and social studies • Analysing economic options and understanding econometrics and social policy choice making • Being able to distinguish between rhetoric and reality in climate change policy and practice.
Proposing Services to end the social isolation and loneliness of older people — a 2008/9 project supported by Calouste Gulbenkian Foundation and Glaxo Smith Kline in the UK and the Royal Society of Arts	• Exploring how older people become involved, supported and reconnected to their neighbourhoods and communities? • Does the key to addressing the problem of loneliness and isolation lie with older people themselves? Will creating the opportunity for them to co-design their own outcomes lead to more appropriate services? • Older people are a mine of information and experience. How can these be harnessed, valued and used? • How can greater social cohesion between generations be fostered? • What are the opportunities for new services, systems, networks and other solutions to counter isolation and support the health and wellbeing issues faced by the growing number of older people in society? • What evidence exists which might point towards viable solutions?	• Collecting and analyzing evidence and data about the socio-economic isolation of older persons in their community • Understanding social history, social policy and public health • Communication skills • Team skills • Evaluative skills, in terms of evaluating data, status claims for knowledge • Critical thinking and analysis • Options evaluation and project management

pointing out that the rigour required to ensure that inquiry-based learning is effective is no less than the rigour to be found in serious scientific work or research in understanding social problems.

For some time, several organisations have been suggesting the idea of an X-Prize for schools based on a 'wicked problem', such as schools working with local communities to reduce and sustain the reduction in water consumption in the community by 15% over the course of a year in exchange for a prize that would benefit the whole school and community — the creation and staffing of a technology design capacity within the school. Schools compete, as they do in the Royal Society's Design Directions Challenge, but the impacts must be demonstrated (rather than proposed) and sustained over time. In such a case, schools become engines of creativity, design and innovation and students are recognised for their life contribution. This seems like a natural extension of a variety of initiatives underway, leveraging the experience of the X Prize Foundation (www.xprize.org/x-prizes/overview) and the offering of several X-prizes, but also moving schools beyond the idea of preparing students for life and engaging them in 'solving' real life challenges while at school.

The Role of Teachers

The conception of learning as the development of the skills of design and innovation as vehicles to create authentic learning required to solve wicked problems for a genuine audience carries many implications for the nature of teaching. Teachers, in this formulation, move from 'instructors' and the adult who is 'in loco parentis' to being imaginers, facilitators, mentors, coaches, guides and brokers for knowledge workers in the community, as well as instructors.

Teachers do still need to teach and 'instruct', but also need to have access to more substantial resources to help their activities. Once they abandon text books and focus on learning as a process of finding relevant knowledge and developing understanding so as to respond to wicked problems and challenges, they can achieve more. The teacher as instructor, coach, guide, mentor, facilitator and adult learner as well as problem solver is a powerful role imbued with professional skills and competences. We refer to this conceptualisation of teacher as 'design consultant'. Key teacher competences for effective work for design-based, problem-focused, authentic learning include, but are not limited to:

- Setting 'wicked problems' which have significant learning content and skills development as students work on authentic learning tasks for a real audience
- The ability to support inquiry as a basis for learning
- The understanding of design as a process at the heart of all learning activity
- The ability to develop both the skills of and disposition towards critical thinking
- The ability to act as a broker and manager for available knowledge in the community, globally and through communities of practice
- An understanding of the critical role of emotional intelligence in the development of a commitment to learning
- Strong knowledge of a discipline (or subject) but an ability to link this discipline to others
- A passion for creativity.

Also required is a high degree of accountability for learning and learning outcomes. By 'accountability', we do not mean managerial accountability (accountability to the system and its management) but accountability to students, parents and the community as well as to their profession — what we could refer to as *professional accountability*. Teachers in this conception are accountable not just for outcomes, but for the design, process of learning and for connecting this learning to community expectations for the work of the school.

This conception of teaching is not new, but carries many implications, especially for teacher education and for ongoing professional development and the school. Let us look at these in the context of a human capital development framework for teachers — the EU Framework released in connection with *Education and Training 2010*, adopted by the Commission in 2004, taking into account the modifications of this document, especially the conclusions of the recent November 2009 Ministerial discussions concerning the professional development of teachers and school leaders. The principles are clear. Teaching should be: (a) a well qualified profession; (b) a set of professional practices within the context of lifelong learning; (c) a profession that permits mobility between countries; and (d) a profession based on partnerships with a range of stakeholders. Furthermore, teaching and teacher education should be evidence-based and strongly linked to a community of practice.

When the statement turns to competence, the Commission is vague. It emphasises the importance of a thorough knowledge of a discipline or subject, and then stresses: (a) the ability to work with others so as to be able to nurture the skills and abilities of every learner and engage in social inclusion; (b) the ability of teachers to work with knowledge, technology and information and in particular to be able to 'build and maintain learning environments' and 'retain the intellectual freedom to make choices and deliver education', making appropriate use of ICT as they support learners in social networks in which information can be found and built; and (c) the ability to work in society — they should be engaged in their community, participate in the tasks of enabling social and skills-based mobility and citizenship. What it does not emphasise, but needs to, is to do all of this in the context of a human capital strategy which enhances creativity, innovation and problem-solving and the skills required to enable learners to develop in a way that helps them to be both actively engaged in designing and assessing their learning and be able to develop their capacities. The November 2009 discussion of teacher education, however, does move in this direction, and stresses the need for specific support for teachers at all stages of their development, and most especially in the early years following their entry into the profession. They will need this support if they are to show competences related to the creativity and innovation strategy outlined here.

Governments which have pursued certain strategies, such as the 'factory strategy' and the 'load-up' strategies described above have generally indicated a lack of trust in teaching as a profession which is capable of enabling learning without strong and centralised 'command and control' curriculum guidance, targets and rigorous accountability measures. Indeed, some have suggested that these strategies have de-professionalised teaching, limiting the scope of professional discretion and control which teachers have over both what and how they engage learners in the task of learning. A key assumption of a focus on innovation and creativity as a strategy for education is that teaching, as a profession, needs to be strengthened, supported and developed. In particular, an investment strategy for teacher

education and professional development is needed. These investments need to focus on broadening the teachers' ability to work with others on wicked problems, strengthening their own design skills and creativity and helping them to see the classroom as a base for learning, not the only place where learning can take place.

It is not about Technology, but It Helps

There is no doubt that technology is changing the way in which young people live their lives, i.e. reshaping social networks, the experience they have of culture, community, information and other experiences, including personal relationships. But this does not translate into a transformation of school systems, schools as organisations or teaching in classrooms, at least not in the near or foreseeable future. In part, this is about cost — it would be expensive to provide the technologies needed for every student. In part, it is about teachers — they do not yet embrace and feel comfortable with technology as a core platform for learning, although there are exceptions (e.g. Djanogly City Academy and Blackburn the Redeemer Church of England Primary School, both named by BECTA as amongst the best schools in England for the integration of technology into the work of the school). But it is also about the technology itself. Software in general and e-learning software in particular over-promise and generally under-deliver.

But technology is moving quickly (CISCO, 2009; Contact North, 2010) and we can expect to see major developments in learning resources, tools to support learning as exploratory and creative challenges, the use of machine learning to support the personalising of learning and instruction, as well as the gradual appearance of robots in our classrooms as teacher aids and supports. We can also expect the overall technology costs of learning to rise commensurately with these developments, as they have in health care systems. Each investment must be weighed in terms not just of utility, but of measurable impacts on learning and the experience of learning. The CISCO review of technology in schools concludes that 'the real potential of technology for improving learning remains untapped in schools today' and that schools are wary of embracing technology, especially social network based learning, since it threatens the traditional role of the teacher.

There is a danger here, as we can see from the earlier description of the *iGen* and its behaviour, that leveraging technology, especially social networks, can be a distraction from the task of learning and skills mastery. However, and more significantly, as most other sectors of the economy are embracing ICT in general and social networks in particular as a means for effectively engaging and communicating with individuals, groups and networks, so must schools. So powerful are these technologies and the way in which the *iGen* and others are using them that traditional forms of news, learning and marketing are changing rapidly, with profound social implications (Hayes & Malone, 2009). Schools seem left behind.

Interactive Smartboard technology is a good example, with many schools using it as whiteboards and not realising its potential as tools of collaborative working and community engagement. The use of learning simulations and games is constrained by the short length of many lesson periods and by the teachers' need to feel in control. A number of studies of augmented reality-based learning, where simulations and games are used as part of a way of understanding a wicked problem in science, for example, require a different approach to classroom work and extended time slots, as well as defined roles for learners and a clearly defined design process. All of these observations are made in the vast ICT and schools

literature, effectively summarised by CISCO (2009). The point is simple: ICT is a major enabler of focused learning and skill development. Technology helps, but is not the focus here: learning is.

Schools as Organisations

Permanently failing organisations have several key characteristics (Meyer & Zucker, 1998). One is that old organisations continue to survive, despite evidence of poor performance — small rural schools being a very good example (Sharkey, 2009). A second is that new kinds of organisations within this category rarely survive (e.g. Risinghill) and are generally quickly assimilated, Third, attempts to change them fail since the competing interests of stakeholders act to create paralysis associated with attempts at permanent change: new targets or processes are quickly assimilated and repurposed so that they resemble 'acceptable' activity for the organisation that knows how to survive change attempts. More recent work on permanently failing organisations, based on cases (Rouleau, Gagnon, & Clouter, 2008), confirms the view that 'sustained underperformance was not the outcome of deliberate or intentional actions in the part of organizational actors but that it was rather the unintended result of as myriad of practices from actors both inside and outside the organization'. It also appears from this same study that the perpetual hope of what might be termed 'outcome transformation' sustains these same actors, despite several decades of evidence that such hope seems a delusion. We can also conceptualise this issue in terms of systems archetypes (Senge, 1990) — repeated and known patterns of systems behaviour — that define what is happening in school systems: that the dominant archetype seems to be 'the tragedy of the commons' (Senge, 1990, pp. 387–388).

School systems can be regarded as permanently failing organisations when a listing of the competing expectations of different stakeholders is taken together. Schools are now: (a) engines of the human capital strategy for a jurisdiction — a labour market organisation; (b) centres for the care and social well being of young people — a social service; (c) a centre for health and wellness, especially in tackling key diseases such as obesity and childhood diabetes — a health care organisation; (d) a place engaged in the development of citizenship and community engagement — a community centre; (e) a place that can support the moral and social development of young people — a social values organisation; (f) a centre for the development of environmental responsibility; and (g) a place where learning takes place. While some these are complementary roles for schools, they do in fact compete as resources are scarce and the competences required to fulfil these expectations are not available in all schools. Thus, school systems fail to meet the expectations of one or more (and in many cases, most) stakeholders.

School systems also often fail to meet educational expectations. Secondary schools, for example, generally remain organised around a particular structure of the school day with 45–50 minute 'periods' (sometimes double periods) in which 'subjects' are taught. Teachers are seen as 'specialists' who teach 'their subject' and students are organised by age and ability. Curriculum is increasingly set by third parties — national governments, curriculum panels or regional (State or Provincial in North America) systems. While some teachers are actively engaged in the setting of these third party curriculum objectives, post-secondary institutions often drive the secondary school agenda, which trickles down to other levels of the school as a system. As demands for content grow, so does the number of objectives for each

curriculum area. Teachers have less and less creative time. As curriculum changes, students have little say in any of this activity, and parents have some role to play (differing by system), but are generally marginalised. Various educational reform and change attempts are made cyclically (in some school systems, in alternate years), often, as a study of literacy performance over 30 years in Britain showed, with little or no impact (Bynner, 2004). Schools are required to subject themselves in many countries to what has become known as 'high stakes testing', which has the effect of corrupting learning and generally obfuscating some of the key challenges faced by the school, as evidenced by the Cambridge University Primary School Review (Alexander, 2009). The results rather than 'real learning' become the focus for the work of the system. Even in educational terms, schools are permanently failing organisations — they do not meet the educational ambitions many have for them.

A redesign of the school so that it focuses on learning as a creative design-based process, with time split in half or whole days focused on project-based work supported by teachers, students, parents and community organisations is part of what is needed (Taylor, 2009). Schools also need to shed many of the non-educational ambitions others have for them. They cannot be effective at being all things to all people. By focusing on wicked problems in health, environment or community, some of these related social functions of the school could be met through a problem-based approach to learning.

Schools also need to embrace technology, seeing the available and emerging technologies as holding the opportunity for transformative change in the processes of teaching and learning. Schools should, according to Law, Pelgrum, & Plomp (2008), act as knowledge hubs leveraging technology available at strategic locations in the community and be fully wireless enabled so that each student can make effective use of low cost digital devices. Some individual schools and individual teachers appear to be early adopters and pioneers of such organisations, but such a system wide development requires a major investment and a change of thinking, both of which seem unlikely. The point here is simple: we can imagine what could happen, since some exemplars exist. The truth is that jurisdictions seeking to ensure that their schools are successful in educational terms need to make these investments in ICT so as to make a different approach to learning possible.

Focusing on the idea that school systems, as currently operated, are permanently failing organisations is not intended to take away from the achievement of specific schools or groups of teachers. The point is that the achievement of the schools' objectives as learning organisations is threatened by the burden of stakeholder expectations. These need to be moderated if learning is to improve.

Barriers to Change

The barriers to change and the widespread adoption of a different approach to teaching and learning, founded on design and the use of wicked problem-solving as the basis for learning, seem to include the following:

- **Groupthink** — schools across the English speaking world appear grossly similar, differing only significantly in the level of available resources and of engagement of teachers and students within them. Their fundamental design is the same. The level of groupthink is in fact remarkable.

- **Accountability Regimes** — high stakes testing at key stages, together with increasing level of third party specification of curriculum have reduced the creativity and quality of learning, especially at the primary education level (Alexander, 2009).
- **De-professionalisation of teaching** — which has occurred over a long period of time and is linked to the growth of accountability regimes, state imposed curriculum, changes in the nature of the relationship between parents and teachers and (ironically) improvements in quality of teacher education (Hargreaves & Lo, 2000).
- **Top Down Change Management** — the imposition, especially in Britain, of new initiatives on such a regular basis as to render local change and innovation difficult and to siphon valuable resources into the projects government deems important nationally, irrespective of what matters locally or what local solutions to national challenges look like. This command and control feature seems to be growing, especially in the US and the UK, despite repeated evidence of its lack of efficacy.
- **Risk Aversion** — teachers rightly fear prosecution or legal harassment under a variety of human rights and related legislations, giving rise to political correctness and the excessive use of the precautionary principle. This is a form of risk aversion. The other key source is the attitude of teachers towards innovation. While a small number are early adopters of innovative practice, most are 'incrementalists' and need strong evidence and support to make changes.
- **Role Confusion** — Hargreaves & Lo (2000) observe that the roles of teacher, social worker, educational psychologist, counsellor, nutritionist and other social functions appear to be becoming blurred, with teachers accepting a broader base of social responsibility for the students in their care: the idea of 'in loco parentis' has become stronger over time. With this role boundary expansion, teachers are often conflicted within themselves about their role and this in turn appears to make them less likely to change any one of their roles in a significant way: they yearn for the simplicity of familiarity on the other side of complexity. There is also system wide confusion as to who does what, fostered by governments in Britain, Canada and the US and elsewhere taking an interventionist role in the day to day work of the school. The meaningful unit of measurement is the school, but decisions are now made about what should be happening in a school some hundreds of miles away (national or regional government), which are then conveyed to people just a hundred miles away (school boards or local authorities) to a Head-teacher or Principal who in turn conveys the new 'instructions' to the staff of the school. These varying layers of responsibility and accountability ensure that schools do not change, despite change being their primary agenda.
- **Lack of Incentives to Change** — in addition to the barriers just listed, teaching is a tough task. While there are regular moments of highly satisfying experiences in classrooms, change has become associated with bureaucracy (Welsh teachers complain that, since high stakes testing was abolished, the new teacher assessment process is so time consuming and bureaucratic that they would prefer the old standard tests). Many teachers wish to focus their energies on teaching and learning and have few incentives to embrace major change.

There are other barriers — resources, absence of effective capital planning, weak technology infrastructure in some regions and school systems, shortages of teachers in key disciplines — but the ones listed here are the key barriers which inhibit disruptive change. They are sufficient, especially in the way in which they interact, to support the dynamics of a permanently failing school system.

When we look at the construct of the permanently failing school systems and review these and other barriers, it should be clear that continuous improvement and piecemeal reform of education — the kind of changes which have been attempted since the mid 1960s in the UK, for example — are not what is needed. What is needed is a transformative break with the past and a repositioning of schools. The good news is that some are starting to do just this. The Royal Society for the Arts (RSA) in the UK began a campaign to enlist schools in a radical approach to teaching and learning and the design of the school in 2008 and has secured the support of many individuals and organisations, as well as schools. Over 200 UK schools have adopted the 'open minds' curriculum built around a similar framework to that described in this article and are showing significant improvements in student engagement, learning outcomes and attested skills as a result (McGimpsey, 2009). The Galileo Network in Canada, which operates globally, also had success in working with some 30,000+ teachers over a decade to develop the mind set represented by the framework described here. But there is a long way to go. We need to transform our schools so that we have access to the human capital skills we need for the rapidly emerging knowledge economy.

Conclusion

The challenges faced by communities are so substantial and the demands for the solution so demanding that we cannot assume that 'doing what we always do' (but slightly better) will produce different results. It is time for bold, imaginative change which embraces a new view of learning as a process founded upon a different understanding of the focus of the curriculum and the nature of knowledge processes. Transformative change, based on some key principles developed in this article is now urgent. A failure to do so will leave Europe's human capital base lagging behind that of other jurisdictions which appear to 'get' the idea that schools must be focused on learning to learn and respond to real world challenges so as to develop 21st century workplace and community-based skills.

The key ideas which should inform the transformation of our school systems from permanently failing into continuously designing and innovative problem solution centres include: (a) a focus on design, innovation and critical thinking as the cornerstones for learning; (b) a focus on real life wicked problems with authentic audiences as the basis for a problem solving curriculum which requires access to disciplined knowledge, synthesising knowledge and knowing how to evaluate knowledge; (c) an ability to leverage technologies in the search for a solution; (d) the development of more than the mind — a disposition for knowing, emotional intelligence, accessing creative talents and skills, engagement, social skills; and (e) participation by students in the design and evaluation of their own learning, coupled with the school being porous — open to the skills and resources of the community as a whole. Schools must be inclusive, creative communities which engender the support of their local community and be beacon-like in giving hope for the future. Our teachers also need to have, in many places, their professionalism restored — they need to be engaged in the design of the curriculum and

have a key role in the assessment of their progress as well as that of their students. Most of all, schools should be different from one another — let others worry about cloning a species, schools should not be clones of one another.

It is difficult to say whether schools, as we now understand them, have the capacity to 'break out', change and develop in the way that recaptures the imagination of students and the communities in which they are placed, but the evidence, despite some bright beacons, is not promising. The relentlessness of a permanently failing school system often leads to two steps being taken forward and one step being taken back. Given the challenges to create a sustainable economy based on different values and a new set of needs for human capital, there is a need to change, but change is not part of the real dynamic of schooling. Many are working hard in individual classrooms and some at a broader systems level to build 21st century learning experiences, but they are struggling and need our support.

REFERENCES

Alexander, R. (Ed) (2009) *Children, their World, their Education — Final Report of the Cambridge Primary Review* (London, Routledge).

Anderson, C. (2006) *The Long Tail — Why the Future of Business is Selling Less of More* (New York, Hyperion).

Asheim, B., Boschma, R., & Cooke, P. (2007) *Constructing regional advantage — platform policies based on related variety and differentiated knowledge base. Papers in Evolutionary Economic Geography (PEEG) from Utrecht University, Section of Economic Geography* (Utrecht, Utrecht University, Section of Economic Geography).

Bartzokas, A. (2000) *Policy Relevance and Theory Developments in Innovation Studies* (Maastricht, United Nations University).

Bynner, J. (2004) Literacy, numeracy and employability — evidence from the British birth cohort studies, *Literacy & Numeracy Studies*, 13, pp. 31–48.

Churchman, C. W. (1967) Wicked problems, *Management Science*, 14, pp. 141–2.

CISCO (2009) *Technology in Schools — What the Research Says — An Update* (Culver City, CA (mimeo)).

Clifford, P. & Marinucci, S. J. (2008) Testing the water: three elements of classroom inquiry, *Harvard Educational Review*, 78, pp. 675–688.

Contact North (2010) *Fast Forward — How Future Technologies are Transforming Education and Training* (Sudbury, ON, Contact North/Contact Nord).

Cornford, A. & Murgatroyd, S. (2006) *Innovation in Canada — Failing the Grade?* http://www.innovationdialogue.com/article_cornfordmurgatroyd.2005.08.19.htm.

Dini, D. (2005) *Game Design and Technology* (Liverpool, John Moores University Workshop on Gaming).

Docherty, P., King, M., Kira, M., Kira, R. & Shari, A. B. (2009) *Creating Sustainable Work Systems — Emerging Prospects and Practice* (London, Taylor & Francis).

Dulchinos, D. P. (2005) *Neurosphere — The Convergence of Evolution, Group Mind and the Internet* (Boston, Red Wheel/Weiser LLC).

Facione, P. (2009) *Critical Thinking: what it is and why it counts*. http://www.insightassessment.com/pdf_files/what&why2006.pdf.

Florida, R. (2002) *The Rise of the Creative Class* (New York, Basic Books).

FRIEDMAN, T. L. (2005) *The World is Flat — A Brief History of the Twenty First Century* (New York, Farrar, Strauss & Giroux).

FRIEDMAN, T. L. (2008) *Hot, Flat and Crowded — Why we Need a Green Revolution and How it Can Renew America* (New York, Farrar, Strauss & Giroux).

GARD, M. & WRIGHT, J. (2005) *Obesity Epidemic — Science, Morality and Ideology* (London, Routledge).

GARDNER, H. (2006) *Five Minds for the Future* (Boston, MA, Harvard University Press).

HARA, N. (2008) *Communities of Practice: fostering peer-to-peer learning and informal knowledge sharing in the work place* (New York, Springer).

HARGREAVES, A. & LO, L. (2000) The paradoxical profession — teaching at the turn of the century, *Prospects*, 30, pp. 1–16.

HAYES, T. & MALONE, M. S. (2009) *No One Size Fits All — From Mass Marketing to Mass Handselling* (New York, Portfolio Books).

HMELO-SILVER, C. E., DUNCAN, R. G. & CHINN, C. A. (2007) Scaffolding and achievement in problem-based and inquiry learning, *Educational Psychologist*, 42, pp. 99–107.

JARDINE, D. W., CLIFFORD, P. & FRIESEN, S. (2006) *Curriculum in Abundance* (New York, Taylor & Francis).

JARDINE, D. W., CLIFFORD, P., KLUTH, P. & FRIESEN, S. (2002) *Back to the Basics of Teaching and Learning: thinking the world together* (New York, Taylor & Francis).

JEFFREY, B. & WOODS, P. (2009) *Creative Learning in the Primary School* (London, Taylor & Francis).

KHER, M. (1997) *Coping with Technological Change* (London, Sage).

KIRSCHNER, P. A. (2006) Why minimal guidance during instruction does not work — an analysis of the failure of constructivist, discovery, problem-based, experiential, and iniqury based teaching, *Educational Psychologist*, 41, pp. 75–86.

KRUGMAN, P. (2008) *The Return of Depression Economics and the Crisis of 2008* (New York, W. W. Norton).

KURZWEIL, R. (2005) *The Singularity is Near — When Humans Transcend Technology* (New York, Viking).

LAW, N., PELGRUM, W. J., & PLOMP, T. (2008) *Pedagogy and ICT Use in Schools around the World: findings from the IEA sites 2006 study* (New York, Springer).

LOMBERG, B. (2007) *Cool it — The Skeptical Environmentalist Guide to Global Warming* (New York, Alfred Knopf).

MARGOLIS, C. & BUCHANAN, R. (1995) *The Idea of Design* (Cambridge, MA, MIT Press).

MCGIMPSEY, I. (2009) Lessons for life, *RSA Journal*, Autumn, pp. 38–41.

MEYER, M. & ZUCKER, L. (1998) *Permanently Failing Organizations* (Newbury Park, CA, Sage).

MONBIOT, G. (2007) *Heat — How We Can Stop the Planet Burning* (Toronto, Anchor Books).

MURGATROYD, S. (2006) Canada's innovation challenge, in: T. C. MACK (Ed) *Creating Global Strategies for Humanity's Future* (Bethesda, MD, World Future Society).

MYTELKA, L. & SMITH, K. (2001). Innovation theory and innovation policy — bridging the gap. *DRUID Conference*. Aalborg.

PALFREY, J. (2008) *Born Digital: understanding the first generation of digital natives* (New York, Basic Books).

PAPERT, S. (1993) *The Children's Machine — Rethinking School in the Age of the Computer* (New York, Basic Books).

PARTNERSHIP FOR 21ST CENTURY SKILLS (2008) *21st Century Skills Education and Competitiveness* (Tuscon, AZ (mimeo)). http://www.21stcenturyskills.org/documents/21st_century_skills_education_and_competitiveness_guide.pdf.

PORTER, M. E. (1990) *The Competitive Advantage of Nations* (New York, The Free Press).

RITTEL, H. & MELVIN, M. (1972). *Dilemmas in a General Theory of Planning* (Berkeley, CA, Institute of Urban and Regional Development, University of Caliifornia, Berkeley).

ROBINSON, K. (2001) *Out of our Minds — Learning to be Creatve* (Oxford, Capstone).

ROBINSON, K. (2006) *Do Schools Kill Creativity?* http://www.ted.com/index.php/talks/ken_robinson_says_schools_kill_creativity.html.

ROULEAU, L., GAGNON, S. & CLOUTER, C. (2008) Revisiting permanently-failing organizations — A practice perspective, *Les Cahiers de Recherche du GePS* 2(1), pp. 17–29.

SAHLBERG, P. (2009) Creativity and innovation for lifelong learning, *Lifelong Learning in Europe*, pp. 53–60.

SAWYER, R. K. (2006) Education for innovation, *Thinking Skills and Creativity*, pp. 41–48.

SENGE, P. (1990) *The Fifth Discipline — The Art and Practice of the Learning Organization* (New York, Doubleday).

SHARKEY, M. (2009) Professor David Reynolds offers his views on the small rural school debate, *Western Mail*, p. 2.

SHUMAKER, S., OCKENE, J. A. & RIEKERT, K. A. (2008) *Handbook of Health Behaviour Change* (New York, Springer).

STEFFEN, A. (Ed.). (2006) *World Changing — A User's Guide to the 21st Century* (New York, Abrams).

STIGLITZ, J. E. (2006) *Making Globalization Work* (New York, W. W. Norton).

SZABO, M. (2002) Education reform as innovation diffusion — development of a theory and test of a model using continuing professional development and instructional technology, *Informing Science*, pp. 1465–80.

TAPSCOTT, D. (2008) *Growing up Digital — How the Next Generation is Changing your World* (New York, McGraw-Hill).

TAPSCOTT, D. & MC QUEEN, R. (1995) *The Digital Economy* (New York, McGraw Hill).

TAPSCOTT, D. & WILLIAMS, A. (2006) *Wikinomics — How Mass Collaboration Changes Everything* (New York, Portfolio Books).

TAYLOR, C. (2009) *A Good School for Every Child* (London, Taylor & Francis).

VEEN, W. & VRAKKING, B. (2006) *Homo Zappiens: growing up in a digital age* (London, Continuum International Publishing Group).

WILLINGHAM, D (2009) *Flawed assumptions undergird the program at the partnership for 21st century skills*. Britannica Blog, March 2nd http://www.britannica.com/blogs/2009/03/flawed-assumptions-undergird-the-partnership-for-21st-century-skills-movement-in-education/.