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21st Century Learning: Research, Innovation and Policy

Directions from recent OECD analyses

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21ST CENTURY LEARNING: RESEARCH, INNOVATION AND POLICY DIRECTIONS FROM RECENT OECD ANALYSES

Learning is central in knowledge-based societies and economies. In many countries there is a push to reflect this by ensuring that reforms of the education system focus more strongly on learning itself rather than simply changing structures and educational organisation. But what does a 'focus on learning' mean in concrete terms? Why is it important? And crucially, is the knowledge base on learning strong enough to help policy-makers shape their direction of educational change? This paper aims to shed light on these questions and provide directions from recent OECD educational analyses.

Rationales for Closer Focus on Learning and on Change

The Need for Lifelong Learning

The inevitability of lifelong learning in knowledge-oriented societies implies that school systems should have different objectives and characteristics than if education were considered to have been completed when a student leaves initial education. Yet in practice, there remains a tendency for school education to be assessed in terms of the achievements and targets that systems have set themselves, rather than their broader success in laying the foundation for lifelong learning.

In the knowledge economy, memorization of facts and procedures is not enough for success. Educated workers need a conceptual understanding of complex concepts, and the ability to work with them creatively to generate new ideas, new theories, new products, and new knowledge. They need to be able critically to evaluate what they read, be able to express themselves clearly both verbally and in writing, and understand scientific and mathematical thinking. They need to learn integrated and usable knowledge, rather than the sets of compartmentalised and de-contextualised facts. They need to be able to take responsibility for their own continuing, life-long learning.

What PISA has to say

According to PISA, school systems are not outstandingly successful in preparing students for the kinds of abilities and skills that build the foundation for lifelong learning. PISA attainments shed light on this question as they are based on a dynamic model "in which new knowledge and skills necessary for successful adaptation to a changing world are continuously acquired throughout life" (PISA, 2003b), rather than measuring achievement in terms of specific curricula. With its focus on reading, mathematical and scientific *"literacy"*, PISA emphasises the mastery of processes, the understanding of concepts, and the ability to function in different situations in each domain, rather than the possession of specific knowledge.[1].

For instance, in only 5 OECD countries do more than two-thirds of young people reach or surpass PISA level 3 in reading literacy - the level which involves comprehension and interpretation of moderately complex text. (The 5 countries are: Canada, Finland, Ireland, Korea, and New Zealand.) The average across OECD countries is 57.1% attaining level 3 or above. In 17 OECD countries, 40% or more do not

1. PISA (Programme for International Student Assessment), has measured the outcomes of education systems at the end of compulsory schooling and related factors every three years since 2000, involving well over 1 million 15-year-olds surveyed and over 60 countries.

achieve at the level 3 threshold in reading literacy, and these low-performing students are in the majority in four of these countries. The countries which have 40% or more achieving at best at level 2 are Austria, the Czech Republic, Denmark, France, Germany, Greece, Hungary, Iceland, Italy, Luxembourg, Mexico, Norway, Portugal, the Slovak Republic, Spain, Turkey, and the United Kingdom. They are the majority of students in Greece, Italy, Mexico, Portugal, the Slovak Republic, Spain, and Turkey. *[PISA2006, Chapter 6]*

Regarding problem-solving, around a fifth of the students in all OECD countries in 2003 could be considered "reflective, communicative problem-solvers", who are able to analyse a situation, make decisions and manage multiple conditions simultaneously, with just under a third being "reasoning, decision-making problem-solvers" and a third counted as "basic problem solvers". This leaves around 16 % considered as "weak or emergent problem-solvers", who are generally unable to analyse situations or solve problems that call for more than the direct collection of information.

Hence, the PISA results provide a *prime facie* case in that too many students are not well prepared for the knowledge society in terms of the different literacies and problem-solving abilities. These arguments are supported by many analysts working in the learning sciences.

The Learning Sciences Argument

When learning scientists (Sawyer, 2006) first went into classrooms, they discovered that most schools were not teaching the deep knowledge that underlies knowledge work. By the 1980s, cognitive scientists had discovered that children retain material better, and are able to generalise it to a broader range of contexts, when they learn deep knowledge rather than surface knowledge, and when they learn how to use that knowledge in real-world social and practical settings. Thus, learning scientists began to argue that standard model schools were not aligned with the knowledge economy.

A set of key findings has emerged from learning sciences research: the importance of learning deeper conceptual understanding, rather than superficial facts and procedures, the importance of learning connected and coherent knowledge, rather than knowledge compartmentalized into distinct subjects and courses, the importance of learning authentic knowledge in its context of use, rather than decontextualized classroom exercises and the importance of learning collaboratively, rather than in isolation.

Traditional models of schooling which are not in line with these key findings and, so runs this argument, are thus not well suited to our knowledge economies and societies. Therefore, learning scientists are calling for a change of today's schools.

The Call for New Approaches from 'Schooling for Tomorrow'

A radical change with a strong focus on learning has not only been called for by learning scientists, but also by some very near to policy-making at different times in the Schooling for Tomorrow programme. The keynote address of Michael Barber to the 2000 Rotterdam Conference, for instance, argued from new driving forces to new models in the following terms:

> The explosion of knowledge about the brain and the nature of learning, combined with the growing power of technology, create the potential to transform even the most fundamental unit of education - the interaction of the teacher and the learner. Moreover, huge social changes, such as growing diversity and population mobility, present educators with new and constantly changing circumstances. As a result, the characteristics which defined the successful education systems of, say, 1975, are unlikely to be those which will define success in the future. (OECD 2003a: 115)

More recently, the need to search for new approaches was articulated forcefully in the conclusions of the Toronto Schooling for Tomorrow Forum in June 2004, especially by one of the Canadian *rapporteurs*, Raymond Daigle:

> For the past 15 years or so, a number of industrialised countries have been implementing sweeping and costly reforms. Although there was some real initial progress, these reforms have ultimately come up against a wall, or rather a ceiling, beyond which further progress seems impossible, leading increasing numbers of school administrators and educators to wonder whether schools do not need to be reformed but to be reinvented. (OECD 2006a: 187-188)

Like Barber's focus on the interaction of teacher and learner, Daigle talks about the micro level – the organisation of teaching and learning in the place we call 'the school'. He does not suppose that 'the school' is necessarily an institution of formal schooling; for if it is to be reinvented it can refer to all number of arrangements through which organised, deliberate learning might take place.

The views of these particular commentators of the need for different approaches to education – 'reinvention' in Daigle's words – share the fundamental belief and are in line with the argument of the learning scientists that the most fruitful area to search for new approaches will lie in close attention to the nature of learning itself.

Insights from CERI and Related OECD Studies on Learning

There have been a number of projects in the Education Directorate of the OECD and in CERI in particular that give insights on learning and provide directions for educational change that is focussing on learning. The projects and their main findings will be presented in this section.

The Neuro-scientific Study of Learning

The purpose of the CERI project on "Learning Sciences and Brain Research" was to encourage collaboration between learning sciences and brain research on the one hand, and researchers and policy makers on the other hand. It has produced two important publications (see: OECD 2002 and 2007), as well as resulted in intensive collaboration, networking and dialogue.

On many questions, neuroscience builds on the conclusions of existing knowledge from other sources, such as psychological study, classroom observation or achievement surveys. But the neuro-scientific contribution is important as it opens up understanding of 'causation' not just 'correlation' and so can help identify effective interventions and solutions. Neuroscience is also generating new knowledge, opening up new avenues. Without understanding the brain, for instance, it would not be possible to know about different patterns of brain activities, e.g. why certain learning difficulties are apparent in particular students even when they seem to be coping well with other educational demands.

The understanding of literacy in the brain is one important area where brain research can inform reading instruction. The dual importance in the brain of sounds and phonological processing, on the one hand, and the direct processing of semantics or meanings, on the other, can inform the classic debate between top-down and bottom-up approaches – "whole language" text immersion and the development of phonetic skills, respectively. Learning sciences have also charted the inverse relationship between age and the effectiveness of learning many aspects of language – in general, the younger the age of exposure, the more successful the second- or third-language learning. This is at odds with the education policies of numerous countries where foreign language instruction does not begin until adolescence. This is a good example where learning science confronts educational practice to ask whether attention to the evidence base calls for significant change to conventional practice.

The study of the brain also highlights the importance of emotions. Emotional states induced by fear or stress directly affect learning and memory. Brain studies have illuminated how negative emotions block learning and have identified the amygdala, the hippocampus and stress hormones, as playing a crucial role in mediating the effects of negative emotions on learning and memory. Some level of stress is essential for optimal adaptation to environmental challenges and can lead to better cognition and learning, but beyond this modicum it activates responses in the brain associated with flight and survival and inhibits those responsible for analytical capacity. Hence if the student is faced with sources of stress in an educational context which go beyond the positive challenge threshold – for instance, aggressive teachers, bullying students, or incomprehensible learning materials whether books or computers – it triggers fear and cognitive function is negatively affected. Therefore, it might end up showing that concepts which place emotional factors to the fore in various forms of "alternative schooling", which had previously been grasped intuitively or philosophically, may in fact have very sound neuro-scientific underpinnings.

One of the most surprising elements to emerge from the recent report on 'Understanding the Brain' concerns the more general, practical issue of how the science of learning should be applied in education. Beyond informing general policy and practice, the eventual application of the results of neuroscience to *individual learners* may be highly beneficial in order to find out such matters as whether a student really does comprehend certain material, or about their levels of motivation or anxiety. Used properly, this individual focus may add fundamentally powerful diagnostic tools to the process of formative assessment and personalised learning, as discussed above. At the same time, studies of the brain show that individual characteristics are far from fixed – there is constant interaction between genetic function and experience and plasticity, such that the notion of an individual's talents/capacity – as if this were fixed and open to scientific scrutiny - should be treated with considerable caution.

Personalised learning

The aim of "personalising learning" is of growing prominence in thinking and policy discussion in some countries. It springs from awareness that "one-size-fits-all" approaches to school knowledge and organisation are ill-adapted to individuals' needs and to the knowledge society at large. This emerging idea is that systems capable of achieving universally high standards are those that can personalise the programme of learning and progression offered to the needs and motivations of each learner. Personalisation can mean adopting a more holistic, person-centred approach to learner development, as well as more demand-driven, market-friendly approaches to system change. In part, it reflects a change in social climate, driven by the affluence and value change that arise from sustained economic growth.

The degree of interest is reflected in the recent OECD/CERI publication, "Personalising Education", [OECD, 2006(b)]. Sanna Jarvela's contribution to that volume summarises some of the findings of research into the nature of learning and aims for education, which the personalisation agenda addresses:

- Collaborative efforts and networked forms of expertise are increasingly needed in the future knowledge society.

- Students need to be able to develop their personal learning needs and individual expertise in the areas which they either feel incompetent or they want to increase their existing expertise.

- Curiosity and creativity are increasingly essential.

- Learning is developed through explicit learning strategies, learning to learn skills, technological capacities for individual and social learning activities, and through learning communities with collaborative learning models.

- Learning needs to be sensitive to contextual conditions, different values and cultural features.

- When technology is seen as an intelligent tool for supporting individual learning, as well as collaborative learning among different individuals, there are multiple ways to expand potential in every student.

Assessment for Learning - Formative Assessment

Assessment for learning may be viewed as an essential element of more personalised approaches to education. It refers to assessment of student progress that is an ongoing part of everyday teaching, rather than a special event. Like other approaches which place learning at the centre – such as mastery learning or intensive tutoring – they have been associated with significant gains in achievement. As well as promising to raise standards, such approaches address equity head on. They do so through the individualisation of teaching and learning strategies and through the continual identification of and responses to students who are experiencing difficulties. Moreover, these approaches are explicitly about developing cultures of learning in schools and classrooms. Yet, they receive far less prominence than conventional forms of assessment such as achievement tests and examinations which are much more in the "one-size-fits-all" mode. All this helps to explain the interest of formative assessment to CERI (OECD 2005a).

Formative assessment is designed to provide teachers and students with critical information about learning needs, help students to assess their progress towards learning goals, and guide teachers to vary their teaching according to needs and goals. It can include data from a number of sources such as classroom interactions, as well as more conventional forms of assessment such as tests and examinations. It provides ways of responding to the aims of enhancing learning and augmenting teacher professionalism rather than assuming that the act of assessment itself, providing summary measures of achievement levels, is tantamount to improvement. Some of the core methods and practices of formative assessment are useful to note as potentially framing elements in enhancing the role of learning in innovation.

"New Millennium Learners"

The CERI project entitled "New Millennium Learners" investigates the effects of digital technologies on school-age learners. The project examines the characteristics of learners and the impact of their sustained use of digital devices and services. Surprisingly little is known about the effects of technologies on cognitive skills, outside of areas related to visual-spatial skills and nonverbal forms of intelligence. The influence of technology use on reasoning capability and judgment has been shown to be relatively small, while there are many studies regarding the influence of technology use on abilities related to information processing, reflective and critical thinking, creativity and, in general, meta-cognitive skills. However, no research review has documented a positive effect yet on the basis of empirical research. It may be that this shows the need for a "neuroscience of children and media" intended to research the impact of digital media on children's brain development, a need that has only been expressed very recently (C.A. Anderson, 2007).

Studies carried out with pre-adolescent children so far seem to indicate the importance of two factors: first, the impulse to experiment and discover, and the consequent lack of fear, that characterises the exploratory behaviour of children at a young age; and second, the predisposition to emulate adults' behaviour. The latter relates in turn to the issue of gender differences of technology use and the consequent impact this might have in education, both at home and in schools. Hence the relevance of this work for enhancing creativity – the natural dispositions of young people to experiment with ICT – alongside constraining factors (in this case the role models provided by too many adults and the discouraging cultures of too many schools).

An issue of competing policy discourses has been identified in the work of "New Millennium Learners". On the one hand, there is the discourse which claims that the real educational benefits of using ICTs are to be seen in domains such as team-working, creativity, problem-solving and the like, in ways very close to the subject of this paper. Yet so long as these are not central to (or even recognised in!) assessment systems such as national examinations, the potential for realising such benefits will always be severely constrained. The second discourse focuses on the factors with a demonstrated impact on boosting educational performance as measured in existing national and international surveys. And, as yet, there is insufficient evidence that ICT use does have an incontrovertible impact on standards so undermining, for those wedded to this discourse, the educational arguments for imaginative ICT use in schools.

However, no-one should expect each and every use of ICT to have a positive learning impact – focusing the question back onto the ways in which ICT is used, in which circumstances, for which students etc – and asking for incontrovertible evidence of the benefits of ICT in a learning society may be no more sensible than to ask for the evidence about the value of books before buying any for schools.

PISA on Approaches to Learning

The PISA findings show that there is a positive association between students' performance and their *approaches to learning*, such as their motivation to learn, their beliefs about their own abilities and their learning strategies. These learning approaches are not only associated with success but can also be viewed as an educational outcome on its own: once students leave school, they have to manage most of their own learning. To do this, they need to be able to establish goals, to persevere, to monitor their learning process, to adjust their learning strategies as necessary and to overcome difficulties in learning. Students who leave school with the autonomy to set their own learning goals are better equipped to become successful lifelong learners. PISA shows that there is a large variation in learner characteristics among students in each school. Relatively few schools succeed in promoting particularly strong approaches to learning among their students. This underlines the importance for schools and teachers to be able to engage constructively with heterogeneity not only in student abilities but also in their characteristics as learners and their approaches to learning.

PISA shows how important positive approaches to learning are for successful and lifelong learning. As argued above, they give rise to concern that many countries are not well prepared for the knowledge society in terms of the literacy and problem solving abilities of their next generation. Thus it is legitimate to ask the question, if the traditional way of learning in many countries, is adequate for the 21st century world.

Exemplary Designs for Learning

The OECD's Programme for Educational Building (PEB) periodically conducts a selection of educational designs to help the planners of educational facilities know what is possible through showcasing leading international examples (OECD 2006c). The international PEB jury chooses the facilities featured in the publication for their fitness for educational purpose, with the new designs fitting one or more of the criteria described below. The facilities' construction, design or use is judged to be noteworthy and to contribute to educational quality. Included are newly built or renovated buildings, extensions or grounds.

Flexibility is the main criterion used which is of interest to this report. This is understood to mean that buildings or grounds are adapted to new forms of learning and research; institutions that make special use of information and communications technology; or special educational facilities. Characteristics include transformable learning spaces, student-centredness, problem-based learning facilities, or provision for students with physical, learning or behavioural difficulties or for "at-risk" students (those whose educational needs arise primarily from socio-economic, cultural or linguistic factors).

There are other criteria considered by the jury. One is *community needs*: institutions that encourage community involvement and/or access by giving multiple stakeholders the opportunity to participate in their design, planning or day-to-day management; by catering to lifelong learning; or by sharing the facilities with students' families or others. Another is *sustainability*: facilities that demonstrate special consideration for the environment through the efficient use of energy, choice of materials, local or natural resources, siting or management. *Safety and security* is a further criterion, as is *alternative financing*, of capital expenditure (including the use of private financing), or buildings whose life-cycle costs are sustainable.

Educational Reform and Innovation

Educational reform and the concept of innovation are clearly related to the search after new approaches to learning. If a school is to change so that its approach to learning is significantly different from what went before it will often need innovation.

Innovation and Knowledge Management

Many studies have argued for more flexible, open forms of learning and of school organisation but while it is not difficult to identify numerous promising examples, it is not so easy to find evidence of more sustained and widespread change. A variety of the factors inhibiting fundamental change to traditional practices has been analysed in OECD/CERI work on knowledge management (OECD 2000a; OECD, 2004a). This suggests that, in general, schools have weak networking and knowledge-sharing among teachers. Spending on educational research and development is very low in contrast to other sectors of activity characterised by the intensive creation and use of knowledge and the application of the R&D is quite limited. Most of the professional knowledge that teachers use in their daily work is tacit: it is rarely made explicit or shared with colleagues. Schools and classrooms are normally isolated one from another rather than interlinked. In short, the message is that too many schools still tend to have only rudimentary knowledge management practices, despite knowledge being education's explicit business.

Reform and Innovation

What is the relationship between reform and innovation? It would be too simple to contrast the enterprise of reform as something directed from the centre and necessarily flawed in contrast with the value of grass-roots innovation. The encouragement of innovation as something isolated might even be a way of diffusing the pressure to change, as Maria Roldau maintained in an earlier 'Schooling for Tomorrow' volume reflecting on 1990s Portuguese developments:

> The "culture of the experiment", conceived and experienced as an exception to the general rule that remains otherwise untouched, made its way deeply into schools and teachers' professionalism…This idea of doing "good experimental things" means predominantly something interesting and innovative that affects only some people in the school or segment of the system but not the routines and the largely dominant practices of teachers and schools. (OECD 2003: 89-90)

Hence, there is need to understand more profoundly the nature of innovation and to focus on its encouragement and sustainability, even bureaucratisation, rather than just gather examples of innovative practice as if by themselves they might inspire a profound change of practice.

Cros rehearsed in her contribution to the 1999 "Schooling for Tomorrow" volume some alternatives for understanding the generalisation of innovation based on very different metaphors and social processes.

In the *Research-development-dissemination-adoption model*, there are clear stages to be followed based on the industrial conception of innovation as a technical process. This assumes linear rationality, planning and the division of labour. Some of the evidence-based approaches to educational policy and practice relate to this industrial conception of diffusion.

In the *epidemiological model*, innovation is understood to spread in a given population rather as an epidemic, following a cumulative S-shaped logistic curve as growing numbers of people are "touched". More recent, naturalist theories of culture see ideas as contagious, not practices. This relates to the discussion of personalisation and the warning of widening existing inequalities. The epidemiological model of change would anticipate such an initial widening of gaps, followed by subsequent re-closing as the innovation diffuses.

Individual decisions and their aggregated social effects lie at the core of the *social-interactionist model* in contrast with the epidemiological model which allows little room for wishes or decisions. This focuses on mechanisms for persuasion, more or less complicated, linked to two key parameters: a) given and received information; b) communications networks.

In the *institutionalisation innovation model*, an innovation has a finite duration and, in the best of cases, it leaves traces of its existence. When it is adopted by an institution, it becomes appropriated so that the innovation loses its newness and energy, is absorbed by the institution, and becomes part of a routine. The innovation is firmly institutionalised when it has found its way into legislation requiring new forms of practice.

CERI has developed analysis of innovation in terms of four "pumps": the "*science-based" innovation pump* (research and development), "*horizontally-organised" innovation pump* (networking), *"modular structures" innovation pump* (organisation), and *"ICT based" innovation pump* to conclude that the potential of all these is underdeveloped in education. Since then, we have moved towards the issue of making educational innovations more systemic, beginning with those in Vocational Education and Training and Digital Learning Resources. We are also actively contributing to the OECD Innovation Strategy.

Confronting the Resilience of Bureaucratic Systems

Tom Bentley, in an analysis recently prepared for OECD/CERI, argues that the challenges being placed before schooling requires identifying and harnessing a particular approach to innovation and system change to recreate the parameters of teaching, learning, participation and organisation. And it requires that we understand properly the sources of bureaucratic and systemic resilience.

For Bentley, what is striking is the formal universal priority now enjoyed politically by education yet with very similar reform goals adopted from country to country, with a strong focus on pushing up quality through standards-based reform. For him, this focus has not resulted in the replacement of the traditional bureaucratic model of schooling.

One explanation is that the familiar model of schooling has become so entrenched that it is simply impossible to overturn it, because of the vested interests and centuries-old habits that hold it in place. Traditional models of bureaucracy are usually characterised as rigid, rule-based, and internally focused. But perhaps the explanation for their *resilience* in fact lies in their peculiar flexibility. Rather than the formal, rational objectives and accountabilities of the institutional system, which is the focus of so much school reform, much recent thinking about the nature of social and economic behaviour has focused on the evolution of complex adaptive systems. That is, human behaviour is adaptive in that it continuously adjusts to changing environments and new experience, even without conscious decision-making.

These organisational structures are functional in the sense of creating the predictability and responsibilities needed in order to organise at large scale. However, they produce boundaries which limit the possibilities of learning, because they limit the scope of inquiry, interaction and information flow, in teaching and learning activities. It results in a combination of stability and incremental change which allows the traditional model of schooling, and of bureaucratic school systems, to adapt continuously to all kinds of external change. It is thus well able to deflect the disruptive potential of almost any innovation, no matter where it is coming from.

The lesson Bentley draws is that, rather than seeking to subvert or bypass the adaptive capacity of existing systems, new reform strategies for improvement need to harness them. They must connect them with the relentless, open-ended pursuit of better learning outcomes, rather than to the implicit preservation of their own core values and underlying structure. For that, we need a new view of innovation and its relationship to system design, and a refreshed sense of the global context into which we should put education.

Conclusions and Concluding Questions

What do CERI projects tell us on the nature of learning and how can this knowledge base help policy-makers to shape their direction of educated change? The key findings of these projects give useful directions for new learning environments in today's schools:

Personalised learning

Learning sciences research suggests that more effective learning will occur if each learner receives a customized learning experience. Different learners enter the classroom with different cognitive structures and as we know from neuroscience, individual characteristics are far from fixed. Therefore, students learn best when they are placed in a learning environment that is sensitive to their pre-existing structures and that is flexible enough to adapt teaching strategies to individual needs. Formative assessment can be seen as an essential element of those personalised learning approaches, as it is characterized by the continual identification of and responses to students' needs.

The importance of motivation and emotion in learning

The motivation to learn, the belief about one's own abilities and the existence of learning strategies are a precondition for successful and lifelong learning, as PISA has shown. These findings are supported by the results from neuroscience: Negative emotions that are caused, e.g. by incomprehensible learning materials, affect cognitive functions negatively.

Use of diverse knowledge sources

Learners can acquire knowledge whenever they need it from a variety of sources: books, technology, and experts around the globe. ICTs have become more and more important in today's world to acquire knowledge. Even though ICTs itself do not seem to have a positive learning impact, it is unquestionable that the use of ICTs itself needs to be a goal of today's schools.

Assessment for learning

Tests should evaluate the student's deeper conceptual understanding, the extent to which their knowledge is integrated, coherent, and contextualized – instead of focussing on the memorization of facts. In addition, the work on formative assessment shows how assessment should not only be used to 'test' student's abilities but to help them assess their own learning progress.

But there are also a number of questions remaining that will inform new CERI work:

1. On the learning sciences, there seems to be a widely-held viewpoint, among those arguing for educational change at least, that this new discipline should provide the evidence base for very different ways of organising education than under traditional arrangements. Are these sciences yet at the stage to offer this profound basis of change? If not, what more exploration and synthesis is needed – where are the gaps? If yes, are there clear messages about the best ways of organising learning to convince the sceptic – what are they? On neither count is the picture yet clear so this is a task which this study can very usefully address.

2. Despite the intense interest for a couple of decades in ICT applications in education, the 'new millennium learner' activity finds a weak evidence base on many basic questions. It is common to observe that ICT by itself is simply part of the whole set of the resources and means available for learning and education: the important question is not whether it is used but how it is used. Similarly, it has long been apparent that much of the use of ICT in schools has been as an alternative way of doing the same thing as before rather than to do something different. If this is the case, for which aspects of learning does ICT permit things to be done which otherwise cannot be? What is its unique "value-added"?

3. Many of the examples of innovative practice identified through different projects take place in the "place called school". It may well be helpful as a heuristic device to use a stereotype construct of traditional schooling – transmission pedagogy, emphasis on the reproduction of facts, strong selection based on binary right vs. wrong answers and uni-dimensional intelligence, negligible cooperation among teachers and among learners, highly standardised organisational and physical units etc. Yet in reality and worldwide, schools cover a very wide range of approaches to learning, just as some of what takes place in out-of-school settings may be even more traditional and close to the stereotype.

The scale of the challenge should not to be under-estimated: it certainly will not be achieved by the optimistic hope that repetition of the need for change will somehow magically bring it about. Education is not a technocratic process which, with a little tweaking here and there, can be shifted to a new paradigm – school systems are both resistant to change and highly adaptable. At the very least, major reform will need to arrive at basic consistency and resolution of the contradiction whereby assessment and accountability regimes may stifle the very approaches to learning and innovation that the reform seeks in principle to encourage.

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