Inspired by Technology, Driven by Pedagogy

A SYSTEMIC APPROACH TO TECHNOLOGY-BASED SCHOOL INNOVATIONS

This report highlights key issues to facilitate understanding of how a systemic approach to technology-based school innovations can contribute to quality education for all while promoting a more equal and effective education system. It focuses on the novel concept of systemic innovation, as well as presenting the emerging opportunities to generate innovations that stem from Web 2.0 and the important investments and efforts that have gone into the development and promotion of digital resources. It also shows alternative ways to monitor, assess and scale up technology-based innovations. Some country cases, as well as fresh and alternative research frameworks, are presented.

Today, sufficient return on public investments in education and the ability to innovate, are more important than ever. This was the conclusion of the international conference on “The School of Tomorrow, Today” organised by the OECD Centre for Educational Research and Innovation with the support of the Secretariat of Education of the State Santa Catarina (Brazil), in November 2009. The conference and this resulting report, share the overall goal of addressing the issue of how education systems achieve technology-based innovations.

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Centre for Educational Research and Innovation

SANTA CATARINA

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Preface

Human capital is at the heart of the innovation process, and our educational systems bear the primary responsibility for nurturing and developing the capacities and innovative capabilities of our fellow citizens. Yet, education is costly; for many countries, educational expenditures constitute a large proportion of public spending. In the light of the current recession and consequent budget constraints that every country faces, governments are looking at ways to maximise the returns on their investments in education. This is not a purely economic perspective: human capital and talent are critical for the development of our societies; thus, investing in education and getting returns on it are important for the well being of all.

The OECD Centre for Educational Research and Innovation (CERI) has been addressing the issue of how education systems manage innovation from two different perspectives. On one hand, in the broader context of the OECD Innovation Strategy,* CERI has analysed what human capital is contributing to innovation as well as how innovation in education can be promoted. On the other hand, CERI has also approached the innovation capacity of education systems from a systemic perspective.** The aim is to better understand the process of innovation and to facilitate the policy process involved in promoting, sustaining, assessing and scaling up innovations. In this respect, it is worth acknowledging that innovation is not only an elusive concept but also extremely context-dependent.

Technology has come to play an integral and important role in education. Despite the current recession, and even seeing an opportunity in it, many countries are now investing heavily again in promoting technology-based school innovations by way of universalising access (one computer per student) and of producing digital learning resources and platforms. If innovation at large can be seen as a means to capitalise on educational investments, the same can be said of investments in technology in education. Countries have to develop systemic approaches to make the most of their confidence in

* More at *www.oecd.org/innovation/strategy*.

** More at *www.oecd.org/edu/systemicinnovation*.

technology-based school innovations because, in the long run, that is probably the most effective way of securing such investments.

The perspective presented in this publication addresses precisely the issue of how technology-based school innovations can not only be fostered and supported but also monitored, assessed and eventually scaled-up – which is even more important from a systemic perspective. In this respect, this publication is an attempt to capture the key issues that matter for a better understanding of how a systemic approach to technology-based school innovations can contribute to quality education for all, promoting a more equal and effective education system. Sufficient return on public investments in education and our ability to innovate are today more important than ever.

In particular, this publication focuses on the novel concept of systemic innovation; on the emerging opportunities to generate innovations that stem from Web 2.0 and the important investments and efforts that have gone into the development and promotion of digital resources; and on alternative ways to monitor, assess and scale up technology-based innovations. In particular, some country cases, as well as alternative research frameworks, are highlighted.

This publication results from a successful co-operation with the State of Santa Catarina (Brazil), which started with an international conference that was convened in Florianopolis, the capital of the State, in November 2009. This conference, organised by CERI with the support of the Secretariat of Education for Santa Catarina, had the overall goal of addressing the issue of how education systems go about technology-based innovations. The meeting had the inspiring title of "The School of Tomorrow, Today". Experts from different parts of the world came together to discuss issues of innovation, policy development, research and technology development with representatives from Santa Catarina.

Francesc Pedró, from CERI, designed and managed that event and is the main editor of this resulting publication. Øystein Johannessen, from the Norwegian Ministry of Education, contributed to both the event and this publication during his secondment period at CERI and well after it. Therese Walsh and Lynda Hawe provided invaluable editorial support.

The Santa Catarina meeting was an extremely successful event, and I would like to express our most sincere gratitude not only for this support but also for the sustained interest that the State of Santa Catarina has had on OECD's work in education, reflected in a number of joint projects. None of these would have come true without the impetus of former State Governor, Luis Henrique Silveira, and both his former Secretary of State for Education Paulo Bauer, as well as Silvestre Heerdt, currently in office, and Director General Antonio Pazeto. Wilson Schuelter, on the Brazilian side, has been

instrumental to the success of these projects as Ian Whitman has been on the OECD side.

I am convinced that this publication will honor the efforts and expectations of all of them and serve the purpose of helping governments and concerned stakeholders to revisit their assumptions about how education systems can maximise the benefits of technology-based school innovations.

Barbara Ischinger

Director, Directorate for Education

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Chapter 1

The need for a systemic approach to technology-based school innovations

Francesc Pedró
OECD Centre for Educational Research and Innovation

While access to new digital technology in schools has increased measurably in the past ten years, it has not been adopted as quickly and intensively as expected despite policy efforts to promote and support technology-based school innovations. This chapter explores possible reasons for this response on the part of schools and teachers from the perspective of systemic innovation. Specifically, it addresses the question of how more effective knowledge management at the system level of technology-based school innovations could contribute to educational change.

The purpose of this chapter is to apply the perspective of systemic innovation to the analysis of technology-based school innovations. For the purposes of this chapter, and consistently with previous CERI works,* educational innovation is defined as ***any dynamic change intended to add value to the educational processes and resulting in measurable outcomes***, be that in terms of stakeholder satisfaction or educational performance. In particular, this systemic approach focuses on how systems monitor and assess innovations and use the results to cumulate knowledge for action in this domain. More specifically, it looks at how innovations are generated and diffused in the system; to what extent knowledge is the basis of these innovations; how knowledge circulates throughout the process; and how stakeholders interact to generate and benefit from this knowledge.

This perspective has been successfully applied to two different areas so far: vocational education and training (VET) (OECD, 2009a), and digital learning resources (DLR) (OECD, 2009b). This chapter attempts to test its limits when applied to the analysis of technology-based school innovations.

The growing relevance of technology-based school innovations

Our increasingly technology-rich world raises new concerns for education while also engendering expectations that schools become the vanguard of knowledge societies. Firstly, technology can provide the necessary tools for improving the teaching and learning process, and for opening new opportunities and avenues. In particular, it can enhance the customisation of the learning process, adapting it to the particular needs of the student. Secondly, education has the role of preparing students for adult life, and, therefore, it must provide students with the skills necessary to join a society where technology-related competencies are becoming increasingly indispensable. The development of these competencies, which are part of the set of the so-called *21st Century skills,* is increasingly becoming an integral part of the goals of compulsory education. Finally, in a knowledge economy driven by technology, people who do not acquire and master these competencies may suffer from a new form of the digital divide that may affect their capacity to fully integrate into the knowledge economy and society (OECD, 2010).

Countries have been supporting technology-based innovations in a variety of ways during the past three decades. Typically at policy level, important efforts are being made in three different directions:

1. Determining the conditions which enable the adoption of technology. These conditions cover a wide range of issues, ranging from the availability of equipment and connectivity, to teacher training,

* More at *www.oecd.org/edu/systemicinnovation*.

technical and pedagogical support, as well as the production and distribution of digital learning materials.

2. Empowering schools and teachers to generate discrete innovations at the school or classroom level by providing different forms of incentives, mostly seed money, through open calls for innovation.
3. Providing support for the research community interested in documenting and analysing emerging educational innovations.

Although little is known about the size and intensity of the investments made in this domain, there are clear indications that the basic conditions for creating a propitious environment for using technology in schools have been there for a long time. By 1999, the limited available data on trends in technology investment and use (technology spending, schools connected to the Internet) were headed up sharply (OECD, 1999). In 2003, more robust data from PISA confirmed exponential growth in the presence of technology in education (OECD, 2006). Between 2000 and 2003, students-per-computer ratios dropped by more than half in most countries and even more in those that were lagging. While less than one-third of secondary schools had Internet access in 1995, it was already virtually universal by 2001, as is currently the case with broadband connectivity in a growing number of OECD countries.

Are education systems failing to scale up technology-based innovations?

With the turn of the century and the burst of the Internet bubble, policy makers had to re-adjust their expectations. As they could not see schools and teachers adopting technology at the desired pace and with the expected intensity or clear-cut evidence of the expected benefits, a certain discomfort, if not skepticism, began to silently propagate. As a result, in many OECD countries the incorporation of technology in education has lost its status as policy priority number one although for a number of political reasons investments have not been stopped. In many respects, the principle of "build it, and they will come" seems to be firmly in place, and education systems keep investing in technology, based on the belief that, sooner or later, schools and teachers will adopt it and benefit from it.

Why, despite the impressive policy efforts made to promote technology-based school innovations, is change at the system level not happening? There is a growing body of literature pointing out the reasons why a majority of teachers is still unable to find feasible ways to use technology to support a much desired pedagogical change. In most OECD countries, when it comes to teachers' access to technology this is no longer a problem, nor is the required baseline of technical skills. As a matter of fact, most teachers are convinced

of the benefits that the use of technology can bring to the classroom. The reasons that explain the resulting paradox are likely to be related to any of the following areas:

1. **Knowledge base**: The question of what works, that is, the connection between pedagogical practices involving technology and their effects on quality, equity and performance, remains ill-addressed. This is partly related to the controversial issue of whether "technology is a blind artifact that can be used for a variety of purposes" or not, but it is also due in part to an ineffective use of the existing evidence, a problem that can be addressed from a knowledge management perspective.
2. **Teacher training**: An ongoing OECD comparative study on how technology is used in teacher training colleges reveals that in most cases these crucial institutions are unable to provide prospective teachers with real hands-on experience in technology-enhanced pedagogies and fail, consequently, to provide clear directions on effective uses of technology in the classroom. Instead of being real showcasing opportunities, teacher training institutions seem to instill a reluctant attitude towards technology – presented as an add-on which would require more time.
3. **Incentives**: Pedagogical change requires a huge investment of effort by teachers, individually and collectively. Education systems provide no clear incentives to support and reward the required effort. In addition, the empirical evidence that could eventually drive this change, for instance, connecting particular uses of technology with improvements in student performance, is scarce and not communicated in proper ways to teachers.

In the following pages, this chapter will address the first area only: how more effective knowledge management at the system level of technology-based school innovations could contribute to educational change.

Why a systemic approach to technology-based school innovations can be useful

The underlying assumption of this chapter is that there is a need to know more about how governments promote, monitor, evaluate and scale up successful technology-based or supported innovations, paying particular attention to the role played by research, monitoring and evaluation, and the resulting knowledge base, both at national and international level. After all, governments also can learn from failures, which in this respect can be just as important as successes. To put it briefly, is there any kind of knowledge management cycle in place in the domain of technology-based school questions? Or, in other words,

do governments (be they at national, regional or local level) have a systemic approach to technology-based school innovations? The knowledge management perspective, previously used by CERI in the area of educational research and development,** emphasises how knowledge is produced, shared and disseminated, and effectively used in any decision-making process whether it be in policy making or in professional practice. Again, it should be stressed that this may be the first time that such an approach has been applied to the analysis of systemic innovation and represents a first step in a promising analytical field.

From a knowledge management perspective a number of questions arise. First, it is unclear how the different strands of policy effort are aligned and interrelated in optimal ways to limit the amount of policy investment that, aimed at seeding innovation, may end up having a very limited systemic impact. A second question is how innovations are monitored and assessed, who does this and where the resulting knowledge goes or becomes disseminated. Third, the role that educational research could eventually play in leveraging knowledge may also be questioned: who decides what kind of research should be funded in this domain? How relevant are the methodologies and results obtained? How are they communicated and eventually used? Particular attention should be given to how countries initiate innovation, the processes involved, the role of drivers and barriers, the relationships between main actors, the knowledge base being drawn upon, and the procedures and criteria for assessing progress and outcomes.

The agenda on systemic innovation and how this report contributes to it

Although there is an increasing interest in the role played by research evidence in policy formation in education, not enough is known about the connections among research findings, public policies, and educational innovations. Previous CERI work on knowledge management, on educational

** The definitions of research and development used then are also applied throughout this project. *Research* is defined as the process of knowledge creation that conforms to the agreed scholarly standards intended to warrant its validity and trustworthiness. In this project, *basic research* is differentiated from *applied research*. The former is driven by curiosity and an inherent interest in a phenomenon or problem, while the latter is consciously designed to solve a problem in policy or practice. In both cases, the process of knowledge creation is carried out within the framework of a theory, which might be either validated or challenged by new research. *Development* is defined as any form of knowledge creation designed to improve practice. Thus, the main purpose of development is to facilitate change in a particular context. A number of educational developments are teacher-lead activities and consist of *enquiry-based activities* that take place within schemes for the professional development of teachers. More at *www.oecd.org/edu/rd*.

R&D and, particularly, on evidence-based policy research (OECD, 2003; OECD, 2004; OECD, 2007) points to the current difficulties experienced when trying to align these three elements. The systemic analysis of innovation in education provides another opportunity to continue and refine the work carried out so far, paying particular attention to the connections between evidence and the innovation processes in education.

In the particular domain of technology-based school innovations, here are three questions that can be developed as research questions:

- **Competing concepts of technology-based school innovation**: How is technology-based innovation defined and understood in different education systems? Why should technology-based school innovation systems be fostered?
- **The dynamics of technology-based school innovation from a knowledge management perspective**: What are the main models of innovation in OECD countries? What are the systemic factors involved?
- **Innovation policies regarding technology in education**: From the perspective of evidence-based policy research, how are innovation policies designed? What is the role of research evidence in nurturing innovation policies? How are these policies monitored and evaluated?

This book is an attempt to contextualise the issues described above by providing an analytical framework made up of three different parts: the opportunities offered by technology, how technology-based innovations are monitored and assessed, and the role of research in documenting innovations.

The first part offers a look at the changing landscape of technology in education and, in particular, to the emergence of the Web 2.0 and digital learning resources to see where the new opportunities and challenges are located. Neil Selwyn's contribution highlights, from a well documented perspective, the changes brought about by Web 2.0 in society, the opportunities that schools might benefit from and, sadly, how little use teachers are making of these opportunities. In doing so, he raises once again the issue of the difficulties that schools and teachers face when trying to digest new technological developments. Finally he rightly asks whether society should really expect them to do it without an ongoing dialogue about educational expectations. The second contribution in this part is made by Jan Hylén, formerly at CERI, who summarises the main findings of an OECD report on the production and use of digital learning resources in the five Nordic countries. Hylén's perspective on this long-awaited development, digital learning resources, is extremely nuanced and raises important questions about the role that governments, public and private providers and the teaching community should play if digital learning resources were to become a standard feature in mainstream

education, thus transcending the stage of being yet another technology-based innovation.

In the second part, the report looks at ways in which the use of technology is being monitored and assessed at national level in order to better support the spreading and scaling up of what works and at what types of evidence are used in this process. This is a crucial question that most education systems have failed to address properly so far. This part presents two different cases. First, John Ainley documents how Australia has had an increasingly complex perspective on this issue, and in particular on how to monitor technology use in schools, as a true recognition not only if the variance in scope and depth that technology-based innovations have across schools and territories. In addition he also suggests the need for substantial progress in the collection of evidence about how young people become equipped with digital literacy skills and, in a broader sense, with 21st century skills. David Hung, Kenneth Lim, and David Huang present the case of Singapore in their contribution. Certainly, this case is quite particular in many respects, and among others in its emphasis on the design, implementation and evaluation of national master plans. In those plans, the support to and the monitoring and assessing of technology-based innovations have been playing an important role and this contribution discusses the different ways in which practitioners, researchers and policy makers have been involved in the process of documenting successful innovations and planning for scaling up.

The report also provides in the third part a fresh look into the role of research by presenting some insights into ongoing efforts to compare the effects of technology use internationally and by exploring the promising avenue of design research. First, Maria Langworthy, Linda Shear and Barbara Means introduce what might be one of the most important international and comparative research efforts to develop and contribute a set of tools to measure educators' adoption of innovative teaching practices and the degree to which those practices provide students with learning experiences that promote the skills they will need to live and work in the 21st century. Still in its initial phase, this major research effort represents an important challenge to existing assumptions about the lack of connection between teachers' innovation practices involving technology and students' achievements. Second, in a completely different vein, Jan van den Akker discusses the benefits and limitations of curriculum design research in this domain and how its results could represent an important contribution to curriculum policies and development. Its main point is not to elaborate and implement complete interventions but to come to (successive) prototypes that increasingly meet the innovative aspirations and requirements. The process is often iterative, cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realisation has been achieved.

A final part presents the main conclusions that can be drawn from all these contributions and the relevant discussions that took part in the Santa Catarina conference. While there seems to be clear support for a systemic approach to technology-based school innovations, particularly when it comes to the complex issue of assessing them and using validated evidence to decide upon their scaling up, there is also the recognition that this new approach challenges predominant assumptions about innovation in education. Governments and teachers alike need to rethink how innovations are supported, monitored and assessed, whether the right strategies and tools are in place and used to their full potential, and finally whether the whole discussion about technology in education has to be redefined in the light of what we all should be caring about: the quality of students' learning.

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Part I

A Changing Landscape

Chapter 2

Web 2.0 and the school of the future, today

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The future of schools and schooling constitutes one of the major areas of current education debate, especially in light of the increasing importance of digital technologies in contemporary society. While having undoubted educational potential, these digital technologies mark a significant area of uncertainty, which are encapsulated in current debates over the place of so-called "Web 2.0" technologies in education. This chapter offers a critical perspective on the emergence of Web 2.0 applications and the hype surrounding their uptake in education. It chapter looks at the changes brought about by Web 2.0 in society, the opportunities that schools might benefit from and, sadly, how little use teachers are making of these opportunities. It concludes by arguing for the need to retain a realistic, if not critical, perspective on schools and Web 2.0 – seeking to find ways of using Web 2.0 technologies to work with the schools of today, rather than against them.

What is Web 2.0 and why is it of educational importance?

Alongside other tags such as the "social web", "modern web" and "social software", the notion of "Web 2.0" provides a convenient umbrella term for a host of recent Internet tools and practices ranging from social networking and blogging to "folksonomies" and "mash-ups". In a technical sense, Web 2.0 can be argued to refer to an increased *socialisation* of Internet tools, applications and services. As Matthew Allen (2008) describes, the notion of Web 2.0 reflects "approaches to the design and functionality of Web sites and the services they offer, emerging in recent years, and essentially describing technological implementations that prioritise the manipulation and presentation of data through the interaction of both human and computer agents". Of course, many computer scientists dispute the technical necessity of such rebranding of the Internet. As Scholz (2008) argues, many claims for the technical novelty of Web 2.0 applications are misleading, with much use of the term driven by a commercial and political "branding mania and obsession with newness". Yet issues of originality notwithstanding, the notion of Web 2.0 is an important framing device for understanding contemporary Internet use – defining "what enters the public discourse about the impact of the Internet on society" (Scholz, 2008).

In particular the "Web 2.0" label reflects the changing nature of contemporary online activity – not least what is described as a "mass" Internet connectivity based around the collective actions of online user communities rather than individual users (see O'Reilly, 2005, Shirky, 2008, Brusilovsky, 2008). Thus in contrast to the "broadcast" mode of information exchange that characterised Internet use in the 1990s, the Web applications of the 2000s are seen to rely on openly shared digital content that is authored, critiqued and reconfigured by a mass of users – what has been described as "many-to-many" connectivity as opposed to "one-to-many" transmission. Put simply, the current prominence of "Web 2.0" within popular and academic discussion of the Internet reflects the growing importance that is being placed on interaction between and within groups of Internet users. In this sense, Web 2.0 re-invigorates many of the debates that began in the 1990s about the transformatory nature of the Internet (Roberts, 2009). Yet unlike the Internet of the 1990s ("Web 1.0" as some commentators have now retrospectively branded it), current debates are propelled by notions of online immediacy where users can get what they want, when they want it – "propelled … by a fantasy of intuition in which the Web already knows what you want because it is you" (Evens, 2009).

The notion of Web 2.0 therefore merits serious consideration – not least in describing what is seen to be a renewed "spirit" and "ethos" of contemporary Internet use. In this sense the individual technological artefacts that are positioned under the Web 2.0 label are of less importance than the wider ideals that are seen to drive their use (Allen, 2008). For example, Web 2.0 can

be seen as conveying a new sense of *economy* of Internet use (based around notions such as the "attention economy" and the provision of ostensibly "free" services in return for greater audience share. Web 2.0 can also be seen as conveying a new sense of Internet *user* – one "who is more engaged, active and a participant in the key business of the Internet: creating, maintaining and expanding the 'content' which is the basis for using the Internet in the first place" (Allen, 2008). Finally, and perhaps most significantly, Web 2.0 can also be seen as conveying a new sense of the *politics* of the Internet – based around libertarian notions of empowered individuals and diminished institutions – "expressed in traditional democratic terms, emphasising freedom of choice and the empowerment of individuals through the 'architecture of participation'" (Allen, 2008). In all these instances, Web 2.0 therefore presents a significant and specific challenge to orthodox notions of technological and institutional arrangements, economic structures and social relations. In particular, Web 2.0 is felt by many commentators to address a number of "participatory deficits" in terms of public/state services – positioning state services around the needs of the individual, with services such as education driven by the individual rather than the institution (Evens, 2009).

Yet despite the significant political, economic and institutional ramifications of Web 2.0 for the formal provision of education, most of the reaction to Web 2.0 within educational circles has been shaped by concerns over learning and individual learners. In particular the privileging of participatory and collaborative group activity within Web 2.0 debate has been welcomed as having clear parallels with contemporary understandings of learning and education, and it is perhaps unsurprising that it has been the learning and pedagogy-related aspects of Web 2.0 that have prompted greatest enthusiasm of late amongst educators and educationalists (see Davies and Merchant, 2009). In particular, it has been argued that Web 2.0 practices have a strong affinity with socio-cultural accounts of "authentic" learning where knowledge is co-constructed actively by learners with the support of communal social settings – taking the form of constantly reassessed "collective agreement" (see Dede, 2008). A great deal of attention has been paid to the personalised and socially situated forms of learning (intended or otherwise) that can be found within Web 2.0 practices, with learners said to gain from participatory experiences in the co-construction of online knowledge (*e.g.* Lameras *et al*., 2009). Thus, Web 2.0 has now come to embody the long-held belief amongst education technologists that learning best takes place within technology-supported networks of learners involved in the creation as well as consumption of content. For these reasons alone, Web 2.0 is now being touted in some quarters as "the future of education" (Hargadon, 2008).

As these latter sentiments illustrate, growing numbers of educational commentators are promoting the educational potential of Web 2.0 technologies in defiantly transformatory terms. Aside from the cognitive and pedagogical

benefits of Web 2.0 use, it is now being argued widely that Web 2.0 tools, applications and services offer schools an opportunity to (re)connect with otherwise disaffected and disengaged learners. For example, as Mason and Rennie (2007, p. 199) reason, "shared community spaces and inter-group communications are a massive part of what excites young people and therefore should contribute to [their] persistence and motivation to learn". These expectations of enhanced motivation and interest are often accompanied by presumptions of an enhanced equality of opportunity, with much popular and academic commentary celebrating (at least implicitly) the capacity of Web 2.0 practices to recast the social arrangements and relations of school-based learning along open and democratic lines. As Solomon and Schrum (2007, p. 8) conclude, "everyone can participate thanks to social networking and collaborative tools and the abundance of Web 2.0 sites … The Web is no longer a one-way street where someone controls the content. Anyone can control content in a Web 2.0 world".

Acknowledging the realities of Web 2.0 use in the school of today

While much hope and excitement surrounds the educational potentials of Web 2.0 tools and applications, many education technologists remain profoundly frustrated by the apparent lack of effective Web 2.0 use in schools. In particular, a consistent picture is emerging from the empirical literature of a noticeable disjuncture between the rhetoric of mass socialisation and active community-led learning and the rather more individualised and passive realities of Web 2.0 use in schools. Concerns are therefore beginning to be raised that Web 2.0 technologies do not appear to be used to their full potential even in relatively well-resourced, "high-technology" classrooms.

This "digital disconnect" between the rhetoric and reality of Web 2.0 use in schools was demonstrated in a recent UK study that deliberately targeted schools that were known to make extensive use of Web 2.0 technologies in their teaching and learning (Luckin *et al.*, 2009). These researchers found most students to be making some use of Web 2.0 technologies, with the most prominent activities in the classroom being social networking sites, Weblogs, wikis, discussion forums and online chat and uploading and downloading of online material. While the study was able to identify some examples of engaging and educationally worthwhile Web 2.0 approaches, a range of impediments to effective use were identified. For example, the study found that teachers were generally cautious in adopting collaborative and communal Web 2.0 practices that many felt could challenge traditional school structures. More importantly, a number of practical barriers relating to technological access, infrastructure and bandwidth continued to impede Web 2.0 use even in the more well-resourced schools. The study also underlined that the educational use of Web 2.0 tools largely depended on the rigidity or flexibility of

the school curriculum. Additionally, teacher fears related to Internet safety and school policy constraints, such as school Internet restrictions and firewalls, were reported to often impose barriers for the adoption of Web 2.0 practices. The study also drew attention to the fact that "learners spend, on average, more time working on school work on a computer outside school than at school itself" (Luckin *et al.*, 2009).

While institutional factors undoubtedly influence the varying *levels* of Web 2.0 in schools, Luckin's study was also significant in highlighting the rather narrow *nature* of Web 2.0 use in school. The study reported that for most students Web 2.0 applications appeared to be used to engage with learning content and other learners in a number of bounded and passive ways, rather than supporting unconstrained active interaction with information and knowledge. As Luckin *et al.* (2009) concluded, even in schools with high levels of Web 2.0 use in the classroom, there was "little evidence of critical enquiry or analytical awareness, few examples of collaborative knowledge construction, and little publication or publishing outside of social networking sites". At best, many students' engagement can be said to lead to what Crook (2008) terms a "low bandwidth exchange" of information and knowledge, with any potential for socially-situated authentic learning realised more accurately in terms of co-operation rather than collaboration between individuals. This, of course, contradicts the rhetoric of "the Web 2.0 ethos of establishing and sustaining collaborative learning communities" (Crook and Harrison, 2008, p. 19).

The unsatisfactory use of Web 2.0 tools in school settings is also reflected in the emerging qualitative research literature on the nature of students' use of Web 2.0 tools in school settings. A growing number of in-depth observational studies also suggest that the compulsion for convivial creation that is seen to lie at the heart of many Web 2.0 practices does not translate easily into many classroom contexts. For instance, recent qualitative studies have illustrated how fostering a spirit of "commons-based peer production" within a community of Web 2.0 users is especially difficult in formal education settings. Grant's (2009) case study approach to the use of wiki technologies by 13- and 14-year-old science and technology students in the UK offers some revealing insights into the clash between the communitarian ideals of many education technology designers and the rather more "closed" approaches towards technology-based learning which are fostered in learners from what Grant (2009) terms their "experience of the broader economy of education and school practices". Similarly, Lund and Smørdal's (2005) earlier study of collaborative wiki construction in Norwegian secondary schools showed how learners preferred to create new entries indefinitely at the expense of editing and improving their own or their classmates' contributions. Students were observed to "not immediately embrace any notion of collective ownership or epistemology but continued a practice where the institutionally cultivated individual ownership persisted" (Lund and Smørdal, 2005, p. 41).

These findings are replicated in other studies of different Web 2.0 tools. For example, Knobel and Lankshear's (2006) study of blogs produced by United States school children revealed a lack of creativity and development of ideas in terms of students' writing process, coupled with a subsequent lack of supportive feedback and commentary from other members of the group. The overall conclusion drawn from the study was what the authors termed as a "why bother?" attitude amongst students and teachers alike. These reactions are, perhaps, unsurprising as learners' participation in school-based learning activities (by their very nature) are coerced rather than chosen. Thus, as Kate Orton-Johnson reasons, the communicative and communal activities most readily associated with Web 2.0 technologies are often, in effect, only "secondary activities" which contribute little to the "real" practices of academic study which remain "grounded in traditional offline activities; reading, note taking and the production of assessed work" (Orton-Johnson, 2007, para 11.2).

Popular solutions for overcoming the "problem" of schools in a Web 2.0 world

It is clear that as they currently stand, some aspects of Web 2.0 use "fit" better than others with the realities of contemporary schools and schooling. From this perspective, increasing numbers of educationalists have therefore started to search for reasons that may underpin the apparent "failure" of Web 2.0 technologies in schools. As is often the case with debates over the "short-comings" of public education, "blame" has tended to be most readily attributed to the perceived deficiencies of educational institutions and practitioners. In particular, the last five years have seen a consensus forming amongst educational technologists that the structure of contemporary schools and schooling is responsible primarily for "emasculating" the potential of Web 2.0 technology (Somekh, 2007). In particular, schools' continued reliance on broadcast pedagogies of various kinds, structured hierarchical relationships and formal systems of regulation is seen to leave them "poorly placed to deal well" with the challenges posed by Web 2.0 technologies (Bigum and Rowan, 2008, p. 250). These criticisms reflect long-running dissatisfactions with schools in the "digital age". As Luke (2003, p. 398) concluded just before the mainstream emergence of Web 2.0 technologies, twenty-first century educators can be accused of failing increasingly to "come to terms with the contradictions" between the complexities and fluidities of digitally-based learning and the persistence of a model of schooling "based on static print/book culture and competitive individualism where learning is geographically tied to a desk … and old-style transmission and surveillance pedagogy".

As such, many practice-based reasons are beginning to be put forward for the poor showing of Web 2.0 in schools. For instance, school buildings are criticised as being architecturally unsuitable for widespread networked and

wireless technology use. Teachers are criticised as being too old, incompetent or disinterested to integrate Web 2.0 applications into their teaching. Students are said to lack the skills or application to make the most of educational (rather than leisure) applications of Web 2.0 applications and tools. School leaders and administrators are felt to lack the required direction or foresight to adopt collective and communal approaches into their school organisation and management. School curricula are criticised as remaining too rigid and entrenched in top-down paradigms of information transfer. All told, the emerging received wisdom amongst many educationalists and technologists is that schools and those within them lack what it takes "to go with the technological flow" (Dale *et al*., 2004).

All of these factors therefore underpin a growing sense in the minds of many proponents of Web 2.0 use in education that schools are simply unable to deal with the challenges posed by Web 2.0 technologies for a number of intractable structural reasons. As the sociologist Manuel Castells was led to conclude recently, "education is the most conservative system as to changing anything since the Middle Ages […] the rules, the format, the organisation of the schools are completely different in terms of interactivity and hypertextuality" (Castells, 2008, n.p). With these thoughts in mind, much of the current debate concerning Web 2.0 and schools is now beginning to focus on how best to re-structure the school to fit with the demands and needs of the technology use. These solutions for change tend to take one of two forms – either the complete replacement of the school through Web 2.0 technologies and practices, or else the reinvention of the school through the use of Web 2.0 tools and practices.

Replacing the school with Web 2.0 technologies

In the minds of some commentators, the seriousness of the "school problem" little choice but to renounce the school as a viable site for learning. In this spirit, growing number of educationalists are concluding that the school is a "dead" site for technology use that will never be able to adapt sufficiently to the challenge and disruption of the emerging forms of Web 2.0 technologies. In this sense the school is conceived as an outmoded technology from a past industrial age that should be dismantled. The education technology academic literature, at least, is increasingly featuring the promotion of reasoned arguments that all of the structural impediments and challenges to technology (*i.e.* the school) must be removed in order to facilitate the realisation of the digital transformation of education.

Indeed, powerful arguments have long been advanced that children are better off learning amongst themselves through Web 2.0 and other Internet technologies – gaining an education through the "hard fun" of creating and playing in online environments rather than being subjected to the "teaching disabled" pedagogies of the conventional classroom (Negroponte, 1995,

Shaffer, 2008). Now Web 2.0 technologies are seen to provide a ready basis for young people's circumvention of the traditional structures of their schools and generally "finding something online that schools are not providing them" as Henry Jenkins (2004, n.p) has put it. For example, Web 2.0 tools such as wikis, social networking and folksonomy software are seen to be able to change education away from being "a special activity that takes place in special places at special times, in which children are instructed in subjects for reasons they little understand" (Leadbeater, 2008a, p. 149). As Nicole Johnson concluded from her study of "expert" Web 2.0 users in Australian secondary schools, home-based Web 2.0 technologies are allowing students to learn *despite* (rather than because) their schools:

> The [students] were able to choose what they learned and when they learned. They viewed the medium in which they did it as a form of leisure. They were also able to choose who and what they learned from – not just what has been set up as exclusive and privileged. They were able to both learn and receive pleasure from their engagement and not have to be concerned about the hierarchisation and failure in relation to how traditional schooling determines competence. They were in fact designing and engaging in their own learning. The teenage experts did not gain a significant amount of learning in the area of computing from formal education and traditional schooling … what is significant is that these participants accomplished (in their own eyes) a level of expertise that schooling had not been chiefly responsible for. Indeed, all of the participants alleged that schooling had had little influence in their trajectory toward expertise (Johnson, 2009, p. 70).

As Johnson infers, Web 2.0 tools are seen as having the capacity to make learning a "looser" arrangement for the individual student – involving a variety of people and places throughout a community for a variety of reasons. In this respect, much faith continues to be vested in twenty-first century Web 2.0 technologies as a catalyst for the total substitution of twentieth century modes of teaching, learning and schooling.

There is a distinct ground swell of support within the education technology community for non-school based technology enhanced learning. From James Gee's celebration of the learning potential of computer games through to Futurelab's "*Out-Space*" agenda, some influential elements of the education technology community appear keen to hasten the decline of the school as the primary site of learning. Indeed a spirit of using digital technologies to bypass traditional education institutions is evident in online services such as the *School of Everything* – a popular Web space in the UK designed to put teachers in contact with learners and therefore aiming to be "an eBay for stuff that does not get taught in school" (Leadbeater, 2008b). Similarly,

NotSchool.Net is a well established and officially endorsed online platform which aims to re-engage UK teenagers otherwise excluded from the formal education system with learning and the pursuit of qualifications. In a higher education context, the *International University of the People* represents a not-for-profit volunteer university offering courses provided entirely online and free of charge based around principles of open source courseware and social networking (Swain, 2009a). Yet rather than being cursory additions to traditional schooling, these examples and others like them are seen to mark the first steps in a radical rethinking and reorganisation of existing structures and organisation of education provision. As Leadbeater (2008b, p. 26) reasons, the imperative of Web 2.0 based education provision

> … require[s] us to see learning as something more like a computer game, something that is done peer-to-peer, without a traditional teacher … We are just at the start of exploring how we can be organised without the hierarchy of top-down organisations. There will be many false turns and failures. But there is also huge potential to create new stores of knowledge to the benefit of all, innovate more effectively, strengthen democracy and give more people the opportunity to make the most of their creativity.

Reinventing the school through Web 2.0 technologies

While these "replacement discourses" are growing in popularity, support remains amongst many educationalists and some technologies for the use of Web 2.0 tools as a means to re-configure and re-invent the school – retaining the overall notion of the school as an institution, but along more fluid and flexible lines of "school 2.0" (*e.g.* Wang and Chern, 2008). Such "reschooling" arguments are advanced most commonly via proposals for the development of digitally aligned modes of schooling that are built around the active communal creation of knowledge (rather than passive individual consumption), and imbued with a sense of play, expression, reflection and exploration. As such, any re-conceptualisation of the school and classroom is deliberately learner-centred – focused on "learner participation and creativity and online identity formation, and how these intersect with, support, or suggest desired competencies, teaching practices, and policies" (Greenhow *et al*., 2009, p. 225). These imperatives to change and reinvent have been expressed most fully in terms of curriculum and pedagogy, as evidenced in the variety of recent proposals from education commentators and stakeholders for "pedagogical mash-ups", "remix curricula" and pedagogies of social interaction (*e.g.* Fisher and Baird, 2009, Code and Zaparyniuk, 2009).

All of these curricular reconfigurations are predicated upon the notion that Web 2.0 technologies are leading to different types of information and knowledge production that is based around fast-changing, non-textual forms

that require new forms of more critical and reflexive information skills and literacies (Buschman, 2009). In this sense the argument is increasingly being made that it no longer makes sense to retain "pre-digital" models of curricular organisation focused on rigidly hierarchic organisation of static content under the control of the teacher. Instead, questions are now being asked in relation to how best to develop Web 2.0-inspired curricula that can be negotiated rather than prescribed, that are driven by learner needs, and based on providing learners with skills in managing and accessing knowledge and being in control of their own learning pathways and choices (Facer and Green, 2007). Thus, growing numbers of authors are now discussing the likely nature and form of "curriculum 2.0" – what Edson (2007) terms as "user-driven education", allowing learners to take an active role in what they learn as well as how and when they learn it. Of course, this "pick and mix approach" to curricular content and form are also seen to present a fundamental challenge to the professional roles and cultures of educators (Swain, 2009b). As McLoughlin and Lee (2008, p. 647) conclude, all of these proposals therefore centre on the need for educators to also change their practices and expand their vision of pedagogy, "where learners are active participants or co-producers of knowledge rather than passive consumers of content and learning is seen as a participatory, social process supporting personal life goals and needs".

All of these arguments reflect a growing belief that technology-based practices of collaboration, publication and inquiry should be foregrounded within schools' approaches to teaching and learning. The mass collaboration seen to be at the heart of Web 2.0 applications has been touted by some commentators as having the potential to "change everything" – even allowing students to rewrite and edit school textbooks (Tapscott and Williams, 2008). For instance, calls continue to be made for the rebuilding of schools to fit with the needs and demands of modern technology. From continuing calls for a "recombinant architecture" to proposals for the re-design of the school environment into "collaboration-friendly", "really cool spaces" (*e.g.* Dittoe, 2006), the notion of redesigning and rebuilding the physical environment of the school continue to gain popularity. Underpinning many of these suggestions is the belief that children should be given more control of their interactions with information and knowledge. For instance, Marc Prensky (2008) argues for a "new pedagogy of kids teaching themselves with the teacher's guidance". This sense of allowing young people opportunities to influence the direction of institutional change is reflected in Donald Tapscott's (1999) advice to "give students the tools, and they will be the single most important source of guidance on how to make their schools relevant and effective places to learn" (p. 11). While none of these authors are suggesting the complete abolishment of school, they are pointing towards a substantial alteration and refocusing of what schools are and what they do.

Towards a more reasoned response to Web 2.0 and the school of the future

At first glance, many of these responses and arguments appear perfectly well-reasoned and sensible. There is an undoubted need to reconcile schooling with the challenges of digital technologies, and it makes sense to sketch out ideas for how systems of schooling that have not fundamentally changed since the beginning of the twentieth century can be brought up to date with twenty-first century life. Yet while compelling, there are a number of inconsistencies to these current debates surrounding schools and Web 2.0 that merit further scrutiny and challenging. In particular, it should be observed that current discussions of Web 2.0 and schools repeat a long-standing tendency in education for exaggerated and extreme reactions to technology that are centred around matters of learning and teaching rather than the wider social, political, economic and cultural contexts of education. Specifically, most educational thinking concerning Web 2.0 reflects an implicit "technology-first" way of thinking, where Web 2.0 technologies are imbued with a range of inherent qualities that are then seen to "impact" (for better or worse) on learners, teachers and schools in ways that are consistent regardless of circumstance or context. In this way, current debates over Web 2.0 and schools are perpetuating a long lineage in educational thinking about technology based around a crude but compelling "technologically determinist" perspective that "social progress is driven by technological innovation, which in turn follows an 'inevitable' course" (Smith 1994, p. 38).

One of the key weaknesses of a technologically determinist reading of schools and Web 2.0 is the tendency to approach technology-based processes as a closed "black box". As such it is important to recognise the ideological underpinnings of the current Web 2.0 drive in education. Indeed, it should be clear from the brief examples in this article that the current discussions over Web 2.0 and schools reflect a number of ongoing debates about education and society that are highly ideological in nature. As such, the forms of Web 2.0-based changes being proposed from within the education technology community are not merely benign technical re-adjustments to school-based learning and teaching. Whether they realise it or not, these proposals are highly political in nature.

For example, much of the current debates about Web 2.0 and the re-invention of schools (what can be recognised as a set of arguments concerning the *re-schooling* of society), position Web 2.0 technologies as a "technical fix" for addressing wider concerns about schools and schooling. Over the last forty years at least, schools have been seen by many commentators as a cause for concern rather than celebration, with accounts persisting in many developed countries of school systems somehow "failing" to perform as well they should. For many policy makers and other commentators, the underperformance of schools has led to what Stephen Gorard (2001) has termed

a prevailing "crisis account" of schooling where educational opportunities are seen to be increasingly polarised, and schools are characterised by poor overall educational standards. In this sense, some sections of the educational community appear to be all too keen to seize upon Web 2.0 technologies as offering a ready "technical fix" to the problem of the failing – or at least underperforming – school. As such, many of the arguments being advanced for Web 2.0 are not driven by a deep belief about the educative power of technology, rather they are driven by a deep concern about the state of schooling in contemporary society. As such, Web 2.0 technologies are being used as a vehicle through which to express a long-standing tendency in western societies to view digital technology as a "technical fix" for wider social problems.

The ideological underpinnings of the *replacement* arguments surrounding Web 2.0 are even more diverse and hidden. In particular, proposals for the Web 2.0 replacement of the school should be seen as feeding into a wider anti-schooling sentiment that has long been implicit in discussion of education and technology, often based upon a range of anti-establishment ideals (see Bigum and Kenway, 1998). In this sense it is evident how much of the current calls outlined above for the discontinuation of schooling in favour of technological means advocate the comprehensive "deschooling" of society along digital lines – consciously updating the arguments of Ivan Illich. Illich's (1971) condemnation of institutionalised learning centred on a set of concerns that educational institutions prevent individual growth and community-based learning. This logic has a direct lineage with contemporary rhetoric of digital technologies and education. As Charles Leadbeater (2008a, p. 44) reasoned recently, "In 1971 [deschooling] must have sounded mad. In the era of *eBay* and *MySpace* it sounds like self-evident wisdom". Indeed, the tendency of educationalists to celebrate individuals' self-determination of their learning *via* Web 2.0 tools feeds into a wider enthusiasm shared amongst many in education for the inherent benefits of forms of "informal learning" that take place outside the control of formal education organisations and settings (see Sefton-Green, 2004). This in turn can be seen as part of a wider societal idealisation of the informal (Misztal, 2000), and the networked individualism of everyday life (see Beck and Beck-Gernsheim, 2002).

In one sense, these arguments stem from a continuation of the countercultural, Californian "anti-establishment" ideals that have underpinned much of the development of information technology since the 1970s. Care should be taken within educational debates to recognise the wider ideological connotations and underpinnings of Web 2.0 discourse. As Danah Boyd (2007, p. 17) points out, for many technologists the notions of "Web 2.0" and "social software" are not used merely as neutral labels, but also as a rallying call for a new age of activities which are made "by the people, for the people" rather than centred around official, institutional interests. Yet while the intentions of many technologists may well be rooted in such relatively benign sensibilities,

it is noticeable that the spirit of these arguments is now being used to support a removal of the state from the provision of public education by a range of more neo-conservative and neo-liberal interests (see Kovacs, 2007, Apple, 2004). For example, it is noticeable how new Internet technologies are beginning to be enrolled into recent neo-liberal arguments for the "end of school" and realising the "dream of education without the state" (Tooley, 2006). Here technology is valorised as an ideal vehicle for the establishment of "a genuine market in education, where there was no state intervention of any kind, in funding, provision or regulation" (Tooley, 2006, p. 26). For example, Tooley (2006, p. 22) talks of "the technological capability to allow inspiring teachers to reach millions of young people [rather than] forc[ing] all teachers into an egalitarian straight-jacket".

From this perspective, many of the arguments for the Web 2.0 replacement of schools could be said to feed into the wider libertarian discourses that have long pervaded societal and political discussion of digital technology – what writers such as Langdon Winner (1997) have termed "cyber-libertarianism". Here the power of technology and the power of the individual (what Kelemen and Smith [2001, p. 371] term "two ideas which lie at the heart of modern civilisation") converge into an argument for the creation of new forms of action and organisation that do not require the appropriation of traditional space or structures. In this sense digital technology is positioned as nothing less than "a moral enterprise set to rescue the world" (Kelemen and Smith, 2001, p. 370), underpinned by an ideological faith in the power of radical individualism, market forces and pursuit of rational self-interest (Winner 1997). All of these sentiments seem a world away from the hopes of more social and communal forms of learning outlined at the beginning of this article.

Conclusion – towards a more critical understanding of Web 2.0, schools and schooling

Any reader of this article should now be clear about the political nature and the political importance of schools and Web 2.0 technology. Debates about schools and Web 2.0 are not simply about matters of Internet bandwidth or the pedagogic affordances of wikis. They are also debates about questions of benefit and power, equality and empowerment, structure and agency and social justice. In this sense, it is crucial to recognise that Web 2.0 is a contradictory, inconsistent and polemic notion – there is no neat, unproblematic "Web 2.0" solution to the deficiencies of twenty-first century education. Instead Web 2.0 is a site of intense ideological competition and struggle along many lines and involving many different interests. For technologists, there is a feeling that Web 2.0 offers a second chance to get the Internet "right" – to correct the wrongs of the dot.com boom and bust and counter the increased

commercial proprietary control of Internet services. For those in business and commerce, there is a feeling that Web 2.0 represents a new struggle for harnessing technology in the pursuit of profit and the harnessing of consumer desires. Similarly in educational terms there is a feeling amongst many learning technologists that Web 2.0 represents the "killer-app" for bringing more desirable forms of socio-constructivist learning to the masses. For some radically minded educators and proponents of democratic education there is a feeling that Web 2.0 represents a ready means to reinvent the provision of education along more expansive, equitable and easy lines. Conversely, for neo-liberal educators there is a feeling that Web 2.0 represents a ready means to wrestle schooling and education away from the clutches of "big government" and the state.

Thus, there is a pressing need to refocus current educational discussion and debate away from how Web 2.0 technologies may be best used to revitalise learning and education in the twenty-first century. As with any other educational technology, Web 2.0 applications do not present a ready "technical fix" to the many social problems faced by contemporary education systems around the world. As Scholz (2008) observes, Web 2.0 "is not and cannot be the all-mighty teacher, healer, and redeemer for everything that went astray in society". Instead, if Web 2.0 is already being used as a ready site for rehearsing many of the wider debates, controversies and tensions about the future of schools and schooling in the twenty-first century, then it makes sense that more meaningful lines of debate can be opened up and pursued. As Michael Apple (2002, p. 442) has reasoned:

> the debate about the role of the new technology in society and in schools is not and must not be just about the technical correctness of what computers can and cannot do. These may be the least important kinds of questions, in fact. Instead, at the very core of the debate are the ideological and ethical issues concerning what schools should be about and whose interests they should serve.

In particular, current thinking about Web 2.0 and schools therefore contains a number of silences and gaps that require recognising and confronting – not least the portrayal of new technology as capable of enacting new arrangements and forms of education. For all its intuitive appeal, the widespread valorisation of informal learning and the technology-empowered individual learner dangerously depoliticises the act of learning (Gorman, 2007), placing far too much emphasis on the disembodied individual learner. Such arguments could be said to present an overly simplistic view of successful education relying merely on groups of like-minded individuals, failing to consider the wider social, economic, political and cultural contexts of the societal act of schooling. A number of critical questions therefore remain unasked and unanswered. For example, if the state is no longer responsible

for the provision of education through school systems, then who is to assume responsibility? What is the role of the private sector and corporate capitalism in the libertarian take on Web 2.0 based schooling? What inequalities of access, skills, resourcing or know-how will remain, and who will be concerned with correcting them?

All of these questions and silences point to the dangers of educational technologists using Web 2.0 as a justification for giving up on the notion of the school with some form of pedagogic authority and responsibility. Instead of rejecting the entire notion of the industrial-era school as it currently exists, it may be more productive to set about addressing the "problem" of schools and technology in subtler and less disruptive ways that work "with" the micropolitics of the school rather than against them. As Wilhelm (2004, p. xii) puts it, "meet[ing] people where they are, not where they would like them to be?" From this perspective, the argument should be considered that it perhaps makes little sense – and is of little practical help – to argue that the only way that Web 2.0 technologies can be properly used in education is by radically altering the school. Perhaps it makes more sense to seek ways of reducing the imperative for engineering widespread Web 2.0-driven changes to the schools of today and, instead, adopt more organic, "bottom-up" approaches to the adjustment of schools and schooling. More attention could be paid, for example, to exploring ways of "loosening up" the use of digital technologies within school settings and introducing a degree of Web 2.0-led informality to schools' digital practice *without* undermining the overall institutionalised social order of the school. Thus instead of calling for a complete learner-driven free-for-all mode of school technology use, careful thought now needs to be given as to exactly how the relationships between formality and informality within schools may be adjusted and altered in ways that can shift the frames of in-school technology use without undermining basic institutional structures and interests.

Above all it would seem crucial that the voices, opinions and desires of learners and teachers are paid more attention to in the further discussion and debates that are now required to advance ways in which such beneficial loosening of school technology use may be achieved.

Indeed, as Daanen and Facer (2007) argue, one of the key issues underpinning any use of technology in education is the simple question of "who decides?" At present it would seem that more often than not, Web 2.0 technology use is something that is being "handed down" to those involved in schools as a *fait accompli* rather than something that is negotiable and malleable. Instead, Web 2.0 technologies are too more important and significant an issue to be simply "handed down" to education. As such a far more inclusive and user-driven debate about Web 2.0 and school now needs to be initiated – involving all of the "publics" of education, not least teachers, learners, parents and other people in the currently "silent majority" of end-users:

> When we look at the capacity emerging technologies may offer to reorganise the institutions, practices and people of education, the issues raised are broader than those raised by the needs of future employers …. As such, we cannot leave discussions of the future role of technology in education only to the technology industry …. Instead, we need to develop the mechanisms for an open and public debate on the nature and purpose of education in the digital age which goes beyond safe slogans such as "meeting the needs of every child" (who can disagree with that?). Instead, we need to confront the fact that longstanding assumptions about what education is for, who conducts it, and how it is assessed, may need to be challenged (Daanen and Facer, 2007, p. 28).

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Chapter 3

Can digital learning resources spur innovation?

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This chapter looks at the results of a study carried out in the five Nordic countries that analysed recent developments in the area of digital learning resources (DLR) from the perspective of systemic innovation. Three different types of innovation are examined: overnment-initiated innovations; innovations initiated by commercial actors; bottom-up innovations (user-generated). The authors point out how technology makes the conditions for DLR innovation different from many other fields of education and present five "embryonic scenarios" illustrating the ways that DLR might be strengthened, promoted, developed and incorporated are presented. The chapter concludes with recommendations directed towards to the production and use of DLR, and to the more general issue of systemic innovation in education.

Background, objectives and methodological approach

Change is taking place at various speeds in different parts of most OECD countries' education systems, with varying drivers and different degrees of premeditation. Although the management of change within complex systems is a key challenge to educational policy makers, the dynamics of innovation in education are not fully understood. So far, not much comparative analysis has been carried out on the policies related to educational innovation, the knowledge base on which they draw, and their effectiveness.

The report forms part of the OECD studies on systemic innovation, including the work on systemic innovation in vocational education and training (VET). The research draws on lessons learned from previous CERI work on Open Educational Resources (OER) in the broader field of digital learning resources (OECD, 2007), and provides a better understanding of the process of systemic innovation regarding ICT in schools. The lessons learned from the OER project include the strength of bottom-up innovations, the importance for the education sector of new business models emerging around free content and new copyright licenses, such as Creative Commons. It is still unknown how these recent developments impact on the production and use of DLR in schools. That institutions and individuals sometimes give away their knowledge for free as OER also highlights the need for countries to take a global view on the production and distribution of DLR – be it commercial or non-commercial resources. Finally, it relates closely to CERI work within the New Millennium Learner project.

The broad aim of this activity has been to review and evaluate the process of systemic innovation in policy making and in public and private initiatives designed to promote the development, distribution and use of DLR for the school sector. In so doing, the activity has brought together evidence on:

1. how countries[1] go about initiating ICT-based educational innovations related to DLR, the players and processes involved, the knowledge base which is drawn on, and the procedures and criteria for assessing progress and outcomes;
2. factors that influence the success of policies aimed at promoting ICT-based educational innovations, particularly those related to the production, distribution and use of DLR, including user involvement in the production process and new actors such as the gaming industry and media companies;
3. user-driven innovations related to DLR, carried out by teachers and researchers, such as innovative production and use of DLR, and how the educational system responds to such innovations.

Accordingly, instead of focusing on discrete institutional innovations, this activity has aimed at a better understanding of how the process of systemic innovation works best in relation to DLR. The innovation process, as defined in the analytical framework of this study, is composed of several phases, such as initiation, implementation, scale up, monitoring, and evaluation. These have been examined in the study together with other factors, such as governance and financing, that influence the development of the innovation process.

In a literature review on innovation in education, OECD (2009a) concludes that the extent to which something is new to a given social context is crucial to identifying innovation. A reform, on the other hand, could be, for example, an official legitimisation of well-known teaching practices. Thus, in line with the already stated pragmatic perspective, the concept of innovation that was used in this study was deliberately open: *innovation is change that is introduced with the aim of improving the operation of education systems, their performance, the perceived satisfaction of the main stakeholders, or all of them at the same time.* The use of such an open definition allows for diversity.

DLR used on a large scale in schools are considered as instances of systemic innovation. One important related question is why education systems should be innovative. This has to do with the possibility of the system to contribute to a societal need of innovation, which is seen not only as a key factor to economic growth but also to social welfare. Innovation relies heavily on the creation of basic knowledge, through both education and science. A well-performing education system facilitates the adoption and diffusion of innovation, by providing human capital for innovation and by innovation within education and training. A well-performing education system also means a system in tune with changes taking place in society, such as globalisation, technological developments and the growing amount of informal learning that is taking place outside the education system. It also needs to take into account individual needs of children, differences in learning styles, special needs, and special talents. To meet these demands our education systems need to improve their operations, performance, and the satisfaction among the stakeholders – hence to innovate.

The methodological approach in the study consisted of two different strands, analytical and empirical. Building on the parallel OECD project on systemic innovation in VET, an analytical framework was developed by the Secretariat. The framework has also made use of the three classic pillars of ICT policy development: investments in ICT infrastructure in schools; investments in in-service training or competence development for teachers (and head teachers); and investments in development of content and software tools. The *empirical strand* was based around a series of country visits and

case studies. Rather than aiming for full country reviews, the project built on case studies developed by a team of international experts on the basis of a Country Background Report. The cases were proposed by each country, discussed with the experts and chosen by the Secretariat.

The study used the term "digital learning resources" (DLR). It was not the aim of the study to do any innovative work related to the definition of the concept, only to state the position of the DLR project regarding some of the issues that arose in the discussion on the concept of digital learning resources. This study has only considered learning resources that are *digital* – either digitised or digital by origin. By a digital resource we understand a resource that exists in binary numeric form, as in digital audio or digital images, videos or software.

Main findings

The examination of the different stages of the innovation process has been of central importance throughout this study. Particularly important is the role of different stakeholders and how they have used various kinds of knowledge during the five phases of innovation: initiation, implementation, scale-up, monitoring and evaluation. These phases need to be understood as a cycle with knowledge playing a central role feeding into all stages and also informing future scale-ups and innovations.

Table 3.1 highlights the kinds of issues that arise when looking at the context, output and role of stakeholders during the different stages of the innovation process. The questions in the boxes guided the exploration of the cases of innovation investigated in this study.

Looking at the five phases of innovation, the following main findings can be reported:

The *initiation phase* can be looked at in terms of the stakeholders that initiated the innovation, for example, whether it was driven by governments or government agencies, local or regional authorities, commercial players or users. When looking at target groups for the innovations and funding models used to foster DLR, no salient pattern arises. With a few exceptions it is clear that the use of academic research has so far been very limited regardless of who initiated the innovation. This is also the case of the involvement of stakeholders in the initiation phase. Almost all innovations in the study are initiated on the basis of "build it and they will come".

The *implementation phase* regarding DLR innovations is somewhat different compared to innovations in other fields of education, including VET. The DLR cases in this study cover a range of resources, from new websites built by a small group of teachers and government initiated campaigns, to

Table 3.1. **The process of innovation related to context, output and stakeholders**

	Process of innovation			
	Initiation	Implementation	Scale-up	Monitoring and evaluation
Context Funding	Who initiated the innovation and with what kind of funding?	Who funded the implementation?	Who is running and scaling-up the innovation and with what kind of funding?	Does the funding mechanism affect the model of monitoring and evaluation?
Context Target groups	Who initiated the innovation and towards which target group?	Are there different knowledge bases used by different target groups?	Is it easier to scale-up when targeting particular user groups?	Does the monitoring and/or evaluation depend on the target group?
Output Radical or incremental DLR	Who initiated the innovation and was it radical or incremental?	Are there different knowledge bases used if the innovation is radical or incremental?	Is it easier to scale-up if the innovation is radical or incremental?	Will the monitoring and evaluation look different if the innovation is radical compared to incremental?
Role of stakeholders	Any role for stakeholders in the initiation process?	Any use of stakeholders' knowledge?	Any role for stakeholders in the scale-up process?	Any role for stakeholders in the evaluation process?

novel ways of organising market offers from companies. In none of the cases in this study are organisational issues, *e.g.* reorganisation of the workflow or workload of a large number of people, of high importance. Since there is no use of pilots before launching an innovation, incremental developments are common.

The idea of *scaling up* a digital innovation is rather peculiar: given that the host organisation has enough bandwidth and server capacity, any number of users can use a digital artefact at the same time. The marginal cost for one new user is close to zero. When talking about the production process, as for a publishing house, scaling up might also mean enlarging the number of DLR they offer.

Issues related to scale-up looks at funding models associated with the sustainability of an innovation. Many have experienced that the ease with which one can initiate or start up a project contrasts with the difficulties of keeping it going in the long run. Sustainability is a key issue particularly for user-generated innovations. Included in this category are development

projects that started with government or EU funding and that turned into commercial companies – sometimes intentionally so by the innovators, sometimes rather unwillingly. A few of the user-generated innovations have found ways of capitalising on user-created content (UCC) in order to scale up their activities. So far publisher and government-initiated innovations have had difficulties in doing the same.

Monitoring and evaluation are essential stages of the innovation cycle. When talking about web-based innovations, two methods are normally used for gathering information on user profiles, frequency of use and feedback on it:

1. web statistics – an easy way to check the number of downloads or users, how long they spend with the DLR, which parts most people use, which web pages they spend most time on, etc.; and
2. user feedback, usually collected in a non-systematic way.

Web statistics and user feedback are used by all actors together with different kinds of monitoring. Publishers and other commercial actors complement these methods with market statistics. Overall, formal evaluations are rare, except for EU funded projects where they are usually mandatory either as part of the project or via an external review by experts.

Looking at the *knowledge base* used in the innovation process, it seems clear that, in the mid 1990s when most government portals were initiated, the knowledge base was weak. Little effort has been made by private or public players to strengthen this knowledge base or to make use of existing research and knowledge in the innovation process.

There is a wide range of *stakeholders* involved in the process of innovation in education, including students, parents, teachers, researchers, schools, local or regional educational authorities, private companies, not-for-profit organisations and charitable foundations, public innovation agencies, government (including state and sub-state agencies), and international organisations. The stakeholders have diverse viewpoints and incentives to innovate or promote innovation, such as increased effectiveness of teaching and learning, opportunities of cutting costs, identification of best practise to improve the system and, in the cases of commercial players, the creation of new markets and enhancing emerging business opportunities.

The issue of incentives is related to the reasons why innovations are initiated. Most government initiated innovations come as a result of either a long-term interest to improve the educational system or an immediate need to respond to criticism. Innovations initiated by the private sector are assumed to be initiated by reason of profit, which of course does not *per se* exclude a will to improve the system. A second reason might be a need to innovate in order to meet the competition coming from other players, although no immediate

revenue can be expected from the innovation. The motive for individual teachers or researchers seems to be a mix of a need to improve their working conditions and an aspiration for professional development and school improvement.

Government-initiated innovations

Four of the five Nordic countries instigated national educational portals in the mid 1990s. In Iceland at first, a private company performed the functions of a national portal before it was bought by the Ministry of Education and turned into a national portal. All the portals have grown incrementally, undergoing several stages of development. When the portals were launched, they all targeted both students and teachers. Although they have chosen somewhat different strategies they all offer similar services (such as thematic DLR and activities for teachers to use, in-service training, links to relevant websites, etc.). Web statistics and non-systematic gathering of user feedback seem to be the most common knowledge base, although at least one (SE1)[2] has used a formal evaluation and another (FI1) academic knowledge on different stages of their development. In addition, informal sharing of knowledge and experience among countries seems to have been another way of informing their development. Looking at other government initiated innovations, the pattern is similar. Only rarely are stakeholders involved and only rarely is academic research used before launch or evaluations during the implementation and scale-up. This contrasts with a much more systematic use of evaluation and research of national programmes and policies of ICT in education.

At the time the national portals were initiated, there were several barriers that posed challenges to their development and implementation:

- The knowledge base for this kind of innovations was weak. There was not much academic, or other codified professional knowledge to build on. This is probably one reason why peer learning among experts from ministries and national agencies, for example under the auspices of the Nordic Council of Ministers and the European Schoolnet, has been so important.
- The involvement of stakeholders seems also to have been weak. None of the Nordic countries seem to have had regular meetings with groups of teachers, principals, representatives of local authorities, educational publishers or researchers before launching their educational portals. Again, the lack of existing models and lessons to learn from at the time should be kept in mind.
- There is no evidence of a demand from teachers or students in the mid or late 1990s to have a national educational platform.

However, there seems to have been one strong driver – a sense of urgency among educational decision makers that ICT would change our societies dramatically. Consequently the schools needed to change as well. This was coupled with the belief that ICT could advance educational reform. As visible from the Nordic countries' national ICT strategies from that time, these arguments, together with the ambition to support economic growth by developing human capital and promoting social development and enhancing social cohesion, were the rationales for justifying investments on ICT in education.

Closely related to this is whether digital competence is considered a key competence for the future or not. Some countries have taken into account the European Commission and European Parliament declaration of digital competence as a key competence for the future (EC, 2006) and this in itself often functions as a driver. Among the Nordic countries this is most explicitly used by Norway which has adopted digital competence as a basic skill in the curriculum, integrated in all subjects. Denmark, Finland and Iceland have, to various degrees, implemented policies to the same effect. In Sweden it is still being discussed how and to what extent this should be done.

A few years after the launch of the national portals, and with the burst of the ICT bubble around the turn of the millennium, political interest was less evident in some countries. In the absence of political leadership, one driving force behind the continuous development and implementation work seem to be senior officials, "intrapreneurs"[3], on the technical side within ministries or government agencies.

In other countries, like Denmark and Norway, the political interest for ICT in education has remained strong, resulting in new government initiatives like ITMF, The Virtual Gymnasium and ITIF in Denmark (Dalsgaard, 2008) and the programme for digital literacy with the inclusion of digital competence as a core competence in all subjects in Norway (Erstad *et al*., 2008).

One more potentially important factor for facilitating the development of DLR is to exploit the concept of a national digital commons[4], the opportunity for individuals and companies to share publicly funded digital resources for non-commercial purposes for free.

Innovations initiated by commercial actors

Looking at commercially initiated DLR it should be noted that most Nordic publishers lack confidence that there is a viable market for DLR. They experience the market as incipient and there is an economic risk involved that should not be underestimated. But, at the same time, it should also be pointed out that there are examples in the Nordic countries of companies making a

living out of producing and selling DLR. It could be said that publishers, who for many years have profited from selling textbooks to schools, have a social responsibility to help develop a country's digital competence. Governments may look at publishers and textbooks in different ways but, to stimulate innovation in the education sector, they should create frameworks to encourage publishers to respond to the concept of digital competence.

Publishers often rightly state that teachers appreciate materials that help them to implement the curriculum. But this does not mean that teachers want textbooks or textbook-related materials only. They also want easy access to pre-sorted information, to modules they can process and apply in ways that fit their own needs and ambitions, to flexible testing tools, practical tips, examples of good practice, and to communities with other teachers. Publishers could provide a new and different range of services and thereby remain as crucial in the education market as they have traditionally been.

Looking at drivers and barriers the most important driver is, of course, an effective demand from schools (*i.e.* that schools are actually prepared to buy DLR at market price). In the absence of an effective demand – caused either by a lack of resources in schools or by lack of interest – it is debatable to what extent publishers can be expected to create a demand and thus a new market. Would it be in their long-term interest to do so? It can be assumed that publishers might have a medium- or long-term interest in introducing DLR, given that the demand is slowly increasing and existing textbooks gradually are getting out of date.

A central driver for innovations on an incipient market seems to be government seed money and public tenders to publishers. Seed money lowers the threshold for publishers to innovate by reducing the commercial risk they are taking.

Furthermore, a key driver is to provide schools and teachers with information about available DLR. The Danish repository Materialeplatformen and the Norwegian DigLib are examples of this. Such repositories could be complemented with ways to facilitate the evaluation of DLR for teachers by providing user-feedback and number of downloads.

If DLR are cannibalising an already profitable textbook market then this can also act as an important barrier for publishers with commercially successful printed textbooks. The difficulty of localising DLR is another possible barrier, although it could also act as a driver for local publishers.

Bottom-up innovations

The user-generated innovations presented in the study are all classic examples of a small group of enthusiastic and skilled teachers or researchers, working hard to make their idea successful.

Although several of them have turned into at least partially commercial companies (*e.g.* School Web (IC3) and Katla Web (IC5), Peda.net (FI2), Lektion.se (SE4)), this seems not to have been the driving force behind the innovation. At least some of the innovators stated during interviews that they would have been more comfortable to continuing their innovation with public funding. They did not look upon themselves as business entrepreneurs. Still, the fact that they succeeded in transforming their initiatives into businesses might become a driver for others. Thus a barrier to user-generated innovations would be created if the education system was not prepared to support or accept such a transformation for financial or other reasons. Education systems with publicly funded clearing houses, rubberstamping teaching materials for schools, might be less flexible in this matter.

From the policy point of view, questions of interest relate to what can be done to promote, nurse and nourish user-generated innovations. There seem to be a number of drivers that can be used in governmental strategies, such as:

- Provide funding for development projects. The drawback of project funding is that a lot of projects happen only because the funding is available, not because there is genuine demand for them. An alternative strategy could be to cluster funding offers like the European Commission sometimes does.
- Provide seed money, *i.e.* small amounts to develop a project idea, write a proposal and pitch this to existing funding agencies.
- Provide transition funding, to help keep innovations afloat once the initial project funding has ended but while people still need time and resources to experiment with different business models. An example of this kind of funding is what the European Commission used to call Accompanying Measures.
- Promote or develop national or international platforms for sharing results and findings partners. The French organisation PrimTICE, which has been set up to enable the identification, description, indexing and pooling of ICTE uses in primary education, is one example. The EU-funded project eTwinning is another example of a service for partner finding.

- Foster and encourage research and evaluation projects so that governments and government agencies as well as development projects or innovative business people can learn from others' successes and mistakes.

Moreover, the opportunity for innovators and entrepreneurs to launch disruptive innovations (Christensen and Horn, 2008) could be a driver of a slightly different kind. Opportunities to initiate disruptive innovations occur when established actors (in this case governments, government agencies and publishers) fail to see that there is a "market" for a different kind of DLR – a kind no one is offering at the moment. At least Lektion.se (SE4) and School Web (IC3) seem to be examples of disruptive innovations, offering products and services of a new and simpler kind than publishers or government agencies. Both present teacher initiated materials – often not as sophisticated or well designed as materials from publishers. The School Web offers about 30 % of its DLR for free to anyone, not only subscribers. The business model of Lektion.se also builds on revenues from advertisements instead of sales to teachers or schools. A similar Swedish case is Skolporten.com, a company offering not DLR but school related information and news for free on their website and through weekly newsletters. According to official statistics, from an independent statistical company, Skolporten.com has some 80 000 subscribers mostly from the school sector.[5] Subscription to the newsletter is free and the business model is similar to Lektion.se – school-related advertisements complemented by other activities, such as organisation of conferences. In terms of establishing themselves as players with impact on a systemic level, these three examples are truly successful.

A number of barriers to *bottom-up innovations* has been identified in this study:

- A possible barrier to bottom-up innovations is the unwillingness of teachers, schools, local or national educational authorities to accept and use bottom-up innovations, *e.g.* innovations lacking a quality assurance from the government or a government agency. Such unwillingness has not been detected in the Nordic countries. There are examples of bottom-up innovations from all five countries which play an important role in respective countries.
- One existing and harmful barrier seems to be a lack of overview of developments and mechanisms to help build synergies between them. A quote from the Finnish Country Case Report illustrates this point. The team of experts conclude that "[i]nnovation is certainly evident but is characterised by small, local projects and initiatives some of which fail to see the value in sharing their results *via* the available national portal. In a decentralised education system, better co-ordination is needed to enable cross-fertilisation and 'mash-ups' of innovations (increasingly necessary in a Web 2.0 world)" (Country Case Report: Finland).

- Low use of existing DLR, or low interest in new ICT developments by teachers, could be expected to be another barrier to innovation. Although most of the cases investigated in this study were developed without much previous demand from teachers or students, lack of demand would surely be a hurdle to innovation in the long run.

As already noted, the Empirica study (2006) investigates barriers to the use of ICT in terms of lack of access to computers and the Internet, lack of adequate content and lack of motivation. According to Empirica (2006), Denmark scores highest among the Nordic countries regarding the propensity among its teachers to take up ICT in their teaching. This study looks at three components affecting the use of ICT in teaching – access, competence and motivation. When looked at individually, the largest differences among the countries is found in motivation. Teachers in Iceland and Sweden, and to some extent in Finland, are much less motivated to use ICT than Danish and Norwegian teachers as well as European teachers in general (see Table 3.2). Reasons for this lack of motivation are not known but, irrespective of them, this deficiency can be expected to affect the use of DLR.

One might speculate if there are virtuous and vicious circles in play – in countries where governments have shown a long-term interest in promoting

Table 3.2. **Teachers' access, competence, and motivation to use ICT**

	Access[a]	Competence[b]	Motivation[c]
Denmark	71.3	93.3	70.9
Finland	63.3	84.9	57.8
Iceland	58.8	88.2	29.4
Norway	68.1	90.9	72.8
Sweden	67.9	93.3	41.4
EU 25+2	60.7	82.0	68.4

a. The higher the value the greater percentage of teachers agree with the statement that their school is well equipped.

b. The higher the value the greater percentage of teachers feels themselves skilled in using ICT.

c. The higher the value the greater percentage of teachers are motivated to use ICT.

Source: Benchmark Access and Use of ICT in European Schools 2006, Empirica (2006).

the use of ICT in education (*e.g.* in terms of government policies and programmes, and participation in international studies in ICT), there seems to be a high interest or motivation in using ICT in general and DLR in particular on the part of teachers. It could also be expected that there is a growing demand from teachers for continuous political support and for more – and better – DLR. Hence, a virtuous circle is created. On the other hand, in countries with weak political interest which might manifests itself in terms of unclear policies and few programmes, teachers might be expected to have less competence and less motivation to use DLR. The vicious circle means that the demand for new ICT policies and programmes, as well as for DLR, would be weaker than in other countries. The recommendations look at ways to break such vicious circles.

Looking at the future of DLR

In the information society it is important that people can use ICT and digital media in working life as well as in their role as citizens and during leisure time. Technological development creates new opportunities for learning, both inside and outside of schools. Young people need to be digitally competent and most often it is expected that the school will furnish young people with the skills needed. To do this, schools need to use and work with different kind of digital tools, not least in the form of DLR.

Furthermore, what used to be a rather stable setting with fixed roles – educational policy makers setting the scene for learning through curricula; educational publishers developing the learning materials building on the curricula; and schools implementing the curricula issued by policy makers and using the textbooks produced by publishers – is now changing. New actors such as media companies, broadcasters, computer game developers, international publishing houses, and software developers are moving in. Teachers are producing and sharing DLR on an unforeseen level. Students are using DLR and digital tools they find for free on the Internet both during and after school hours, often challenging what the teacher and the school offers. At the same time, new digital divides are emerging, this time dividing those who can master the flow of information, sift, digest and use it, and those who are unable to protect their integrity on the Internet and get lost in the new digital landscape. Education policy makers need to respond to these challenges.

The annual Horizon Report (2009) describes "the personal web" as one of the strong trends in higher education within the next two to three years. The personal web means that "computer users are assembling collections of tools, widgets, and services that make it easy to develop and organise dynamic online content. Armed with tools for tagging, aggregating, updating, and keeping track of content, today's learners create and navigate a web

that is increasingly tailored to their own needs and interests". In compulsory schooling this trend is probably more related to teachers. But it is clearly challenging the way teachers, learners and publishers are working today. So far, this report has described how governments, publishers and groups of teachers and researchers are producing DLR at the moment. But the changing landscape makes new scenarios for the production and use of DLR possible. In such scenarios, new models of production, new business models and new ways of distributing and using DLR should be taken into account. Below are five embryonic scenarios on novel ways of producing, distributing and use DLR.

The first builds on the Norwegian initiative NDLA which describes an interesting case of how teachers are more closely involved in production. A number of regional educational authorities has teamed up and decided to produce some DLR on their own instead of spending all their money on DLR produced by publishers. They ask some of their teachers to do the authoring, with the same kind of salary as before. Since the teachers are producing DLR on behalf of their employer, using the tools of the school, all the intellectual rights to the materials belong to the local educational authority. These materials are mixed with professionally produced ones, bought by the authorities from publishers and media companies. All materials are published in digital format. The authorities have decided not only to share the materials among themselves but to publish all materials using Creative Commons licenses, which means that other teachers cannot only use the materials in their teaching but also adapt and reuse them. This is in many ways challenging the role of publishers in the educational market.

The second scenario is intended for local educational authorities. They could ask a teacher or a consultant to gather Open Educational Resources, *i.e.* materials already free for schools and materials they have the right to use in schools (usually because a Creative Commons license is used). The focus in this case is on gathering existing materials, not on their production. The work would be to compile materials to fit the local needs of the schools. Since the materials are open, local educational authorities could share these materials among each other, given that they also spend resources on tagging the DLR with metadata making it possible to search for them and find them on the Internet.

The third embryonic scenario is directed towards publishers who need to respond to these challenges. One way of doing this could be to disaggregate content and offer smaller chunks of learning materials rather than fully fledged productions. Individual teachers, schools or local educational authorities could then subscribe to the repository and authoring tools and use these learning objects as they choose. On top of offering the content, publishers could provide the service of putting it together in a way that fits the local

needs. This is similar to the OER model described above, but it would have an extra quality stamp both on the content and on the compilation process. The important thing is that again the one-size-fits-all model is abandoned.

The fourth scenario is also intended for publishers. They could work in close co-operation with one or several local educational authorities and the local teachers, taking much the same role as NDLA in the Norwegian case. The role of the publisher would be to offer some of the content, to lead the compilation process putting its knowledge and quality stamp on the materials. The business model is that schools or local authorities would pay for the service as well as the content from the publisher.

The final scenario focuses on teachers. Teachers could very well work without both local educational authorities and publishers. The Internet opens up new opportunities for teacher associations or similar organisations to play a role related to educational materials. One example could be a national association of teachers in mathematics or science starting an OER community and repository, inspiring and promoting teachers to develop and share resources among each other. The success of Lektion.se (SE4) is an example of the possible success of a teacher initiated and driven community. And, as described by the Horizon Report (2009), technological developments make it increasingly easy to find, sift and keep track of content.

It is hoped that the ideas presented in this chapter, as well as the findings and analysis of this report, will help to move forward the research agenda on the use and effects of DLR and ICT on learning, given the growing importance of new technologies and digital media in modern societies.

Conclusions and policy implications

There are two kinds of conclusions and recommendations emerging from the report. The first relates to the production and use of DLR, and the second to the more general issue of systemic innovation in education.

Governments can take different roles in innovation, from creating favourable conditions to fostering or being leaders of innovation. They often take several roles at the same time, depending on their needs and the political interest in promoting innovation in the area in question. The policy recommendations cover all of these potential roles.

In order to create enabling conditions for innovation in the area of DLR, governments could:

- establish a coherent vision on digital competence;
- make publicly funded information freely available for commercial and other use;

- join up innovation initiatives making researchers and entrepreneurs visible;
- establish a forum for dialogue between innovators and stakeholders; and
- support the building up of a formal knowledge base for DLR development.

Furthermore it is recommended that governments federate existing educational portals to provide support services of different kinds in order to facilitate access and use of DLR, both commercial and non-commercial, and to promote DLR design and use by teacher training institutions both for initial and in-service training. Local authorities are recommended to increase teacher awareness on the existence of Open Educational Resources and to invest in training on fair use for teachers and school managers as well as to value the use of DLR for teacher professional development.

To foster innovation governments are recommended to supplement seed money with development funds and transition funding for development projects; and to promote co-operation between public and private players for DLR development.

To be leaders of innovation governments are recommended to consider the relative circumstances of their country when deciding about initiating new DLR or instead supporting initiatives of others. In the case of smaller countries for example it may be preferable to identify DLR at European level and to focus more on localisation. They also need to rethink their role in relation to communities using more of an "engagement" and less of a "delivery" strategy.

One conclusion related to the discussion of innovation in education consists in recognising that technology makes the conditions for DLR innovation different from many other fields of education. It seems clear that successful ICT-based innovations spread fast and that small, user-generated innovation may have a systemic impact. Moreover it is difficult to plan for scaling-up ICT-based innovations since the end-users decide the success of innovations.

Notes

1. "Countries" are not necessarily to be equated with "governments". In this field in particular, a range of significant agents and institutions are likely to be involved, with much of the impetus coming from the bottom up.
2. A list of the case studies can be found in Appendix 3.A.
3. Wiktionary defines "intrapreneurship" as the practice of applying entrepreneurial skills and approaches within an established company (*http://en.wiktionary.org/wiki/intrapreneurship*).
4. The Nordic countries have long traditions in the use of common land. It may be common usage of natural resources in forests and on mountains, such as hunting, fishing and berry picking. The idea of digital commons, which originated in a Norwegian governmental white paper, is to build on the sharing culture and reuse of resources on the Internet. The digital commons should be as large as possible and contain information and material of high quality. It should focus on the needs of the users. It should be free for the individual user and permit reuse of digital resources for non-commercial purposes.
5. See *http://ts.se/Public/CirculationNumbers/EmailCertificateList.aspx*.

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Annex 3.A1

Cases studied in the DLR project

Country	Name	Category	Designation
Denmark	EMU	The national educational portal	DK 1
	Subscription to DLRs	Publishers selling packages of DLRs to schools	DK 2
	ITIF (ICT in the public school)	Government programme with, among other things, resources for private companies to produce DLRs	DK 3
Finland	Virtual School including EDU.fi	The national educational portal	FI 1
	Peda.net	Research and development project providing schools with DLRs	FI 2
	Areena	The digital extension of YLE´s televised production	FI 3
	Abitreenit	Practice material for students preparing themselves for the matriculation examination produced by YLE	FI 4
Iceland	The Educational Gateway	The national educational portal	IC 1
	The National Centre for Educational Materials (NCEM)	National agency developing and translating educational materials which are sold to schools.	IC 2
	The School Web	Private company developing and selling DLRs to schools	IC 3
	The Language Studio	Support and materials for distance teaching of Nordic languages, supported by the city of Reykjavik	IC 4
	The Katla Web	Support and materials for teaching Icelandic as a second language. School subscriptions	IC 5
	IceKids	Provide Icelandic families living abroad with learning resources for studying their mother tongue. Family subscription	IC 6
Norway	Utdanning.no	The national educational portal	NO 1
	Aschehough	Publishing house with a web portal called Lokus.no	NO 2
	You Decide	Government initiated campaign on the subject of data protection	NO 3
Sweden	IT for Teachers	The national educational portal	SE 1
	The Course Hub	Government initiated DLRs repository for teachers	SE 2
	UR and the Media Bank	Radio and TV clips from the education broadcasting company	SE 3
	Lektion.se	Teacher created website and community for teachers exchange of lesson plans	SE 4

Part II

How Technology-Based Innovations are Monitored, Assessed and Scaled Up

Chapter 4

Monitoring and assessing the use of ICT in education

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This chapter documents how Australia has had an increasingly complex perspective on the broad issue of monitoring and assessing the use of technology in education. In particular, the Australian experience documents how to monitor technology use in schools in the context of a complex governance system, as a true recognition of the variance in scope and depth that technology-based innovations have across schools and territories. In addition, the chapter elaborates how Australia is addressing the need for substantial progress in the collection of evidence concerning how young people become equipped with digital literacy skills and, in a broader sense, with 21st century skills.

Context

Population characteristics

Australia has a population of 21 million in an area of 8 million square kilometres. Although the overall population density is low, it is a highly urbanised society. Outside the cities, the country is sparsely populated; 30% of primary schools have fewer than 100 students and 30% of secondary schools have fewer than 500 students. Australia is classified as a high-income country: literacy among adults is nearly universal, nearly half of the population has completed secondary school, and 32% hold a university qualification. Although the Australian population is mainly of European background, immigration has produced greater ethnic and cultural diversity. One-fifth of the population (22%) was born overseas and a similar percentage (21%) speaks a language other than English at home. About 4% of Australian school students are indigenous, and some of them live in isolated communities. In recent years, Australian people have embraced the use of information and communication technologies (ICT). According to recent surveys conducted by the Australian Bureau of Statistics, more than three quarters (78%) of Australian households have access to a computer at home (up from 48% in 1998), 72% have home Internet access (up from 16% in 1998), and 62% have broadband Internet access (ABS, 2009).

Education systems

Australia does not have a single national education system. Eight jurisdictions (states and territories) are each responsible for their own educational administrations although the overall structures are similar. Collaboration on matters of policy takes place in a council of ministers of education, and the role of the federal government has increased during the past two decades. Over the past two decades there has been a shift towards a greater role for national approaches, and this is reflected in the support for ICT in education. The Australian Information and Communications Technology in Education Committee (AICTEC): a national, cross-sectoral committee responsible for providing advice to all Australian Ministers of Education and Training on the utilisation of ICT in education and training (MCEETYA, 2008). It has recently enlarged its responsibilities to include advising on implementation of the Digital Education Revolution (DER).

In addition to the fact that states and territories are responsible for the provision of school education one-third of school students are enrolled in non-government schools. In 2009, non-government schools enrolled 34% of the students (31% of primary and 39% of secondary school students), a proportion that has risen steadily since 1970 (ABS, 2010). The uptake of computers in teaching during the 1990s was very strong in independent non-government

schools, some of which introduced programs in which each student had their own laptop computer (Shears, 1995).

ICT use at home and school

In general Australian students are frequent users of computer technology. According to data from PISA, 77% of 15-year-olds in 2006 used a computer at home "almost every day", and 24% used a computer at school "almost every day" (Anderson and Ainley, 2010). These data indicate that Australia is one of a cluster of seven OECD countries with significantly high levels of student computer use at school (16% or more using computers at school daily):, Australia, Austria, Canada, Denmark, the Netherlands, New Zealand and Norway.

National surveys conducted as part of the national assessment program indicate that nearly half of the students in Grade 10 (48%) used a computer at home at least once every day and a further 25% used a computer at home almost every day (MCEECDYA, 2010). The corresponding figures for Grade 6 students were 30% and 25%. School use of computers is less frequent. Ten per cent of Grade 10 students used a computer at school at least once per day with a further 22% using a computer at school almost every day. The corresponding figures for Grade 6 students were 8% and 13% (MCEECDYA, 2010).

Australian schools are well provided with computer technology. Data from PISA conducted in 2006 indicate that Australia has one of the highest levels of computer availability in secondary schools among the OECD countries, with an average of 2.9 students per computer (OECD, 2007). This ratio had 3.3 students in 2003 and 4.5 students per computer in 2000 and indicates a substantial improvement in school computing resources in Australia over six years. Other countries that have ratios of three to four students per computer are Austria, Canada, Hong Kong, Iceland, Japan, Korea, Luxembourg, New Zealand, Norway, Sweden, United Kingdom and United States (Anderson and Ainley, 2010). Findings from the Trends in International Mathematics and Science Study (TIMSS) suggest that 78% of Grade 4 students also had high levels of access to computer technology in their classrooms. This is behind only Denmark (91%), New Zealand (89%), Scotland (89%) and Japan (84%) and is similar to Singapore (80%), England (77%), Sweden (77%) and the United States (77%) (Martin, Mullis and Foy, 2008).

Building interest in the educational use of ICT: 1990 to 2000

There were several initiatives at state level designed to promote the uptake of ICT in schools. The following initiatives were introduced in Victoria.

A *Navigator Schools Project* highlighted ICT practices and served as a focus for professional development and visits from neighbouring schools.

A two-year study of the navigator schools project suggested that the introduction of ICT to those schools had effects on staff and students. Teachers changed in their behaviour and outlook when ICT was introduced with an accompanying reform and collaborated in using the technology to reformulate their approaches to teaching and curriculum (Clarkson, Dunbar and Toomey, 1999).

A *Notebooks for Teachers and Principals Program* which supported principals and teachers to integrate learning technologies into school classroom and administrative practices. In return for leasing a notebook at subsidised rates teachers were expected to demonstrate a commitment to ongoing professional development in the use of learning technologies. An evaluation indicated that by June 2002, 91% of all teachers and principals had a notebook computer and 85% of those participants reported routine use of computers at school (McDougall, Nicholson and Marshall, 2001). A similar program was introduced in other states.

One of the ventures that featured in the 1990s was the introduction of programs in which each child had a notebook computer. These received greatest attention in independent non-government schools that introduced them on a schoolwide basis (Shears, 1995), but similar programs were also tried in selected government schools (Rowe, 1993) and selected classes in government schools (Ainley, Bourke, Chatfield, Hillman and Watkins, 2000).

Educational goals and plans for ICT in education

The importance of ICT in education was given formal recognition in the emphasised in the Adelaide Declaration of Australia's National Goals for Schooling which stated that when students left school they should be: "confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society" (MCEETYA, 1999). This theme continued in the later Melbourne Declaration on Educational Goals for Young Australians which was released in December 2008 (MCEETYA, 2008). The Melbourne Declaration asserted that "in this digital age young people need to be highly skilled in the use of ICT".

In 2000, the MCEETYA adopted a school education action plan titled Learning in an Online World (MCEETYA, 2000), which was updated as Contemporary Learning: Learning in an Online World (MCEETYA, 2005a).

Overall, the plan established areas in which strategies were to be implemented by:

- developing teacher competence in using learning technologies effectively;

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

Supporting the use of ICT in education

Networked resources and information gateways

Education Network Australia (EdNA) was established (by Education.au) to enable Australian educational institutions (schools, universities and technical institutes) to adopt new ICT services and to disseminate and produce content and services relevant to the Australian experience. The EdNA Directory Service provided free access to quality education resources on the Internet for all sectors of Australian education. EdNA operates an information gateway – EdNA Online (*www.edna.edu.au*) – which provided access to resources, online networks, the EdNA sandpit, personal learning space, web conferencing, and access to education news through bulletin boards and RSS feeds.

The intention behind Education Network Australia (EdNA) was to enable Australian educational institutions to adopt new information and communication services and technologies, and to disseminate and produce content and services relevant to the Australian experience. The EdNA Directory Service provided free access to quality education resources on the Internet, for all sectors of Australian education. Effects of geographic isolation are alleviated through this initiative, with the opportunity it affords for collaborative access to national and international curriculum materials.

Education.au supported collaborative projects such as the OzProjects website (which supported teachers in joining projects, creating their own projects, and choosing appropriate online tools for students), the International Learning Quest Challenge (which provided opportunities for teachers to integrate use of Internet into existing curriculum programs), and the Netd@ys International Online Project (which promoted student use of new media in the areas of youth and culture).

Most state authorities have established networks that link schools and education agencies. Through these networks, teachers have access to online resources provided by the state as well as resources provided through EdNA. In Victoria, networking was a central priority, with all schools connected to a Wide Area Network and a range of services including the Internet. A digital resource centre was established as a means of delivering

multimedia curriculum resources. A Curriculum Development and Learning Technologies division developed materials and programs to support state curriculum frameworks. These are accessible through the Education Channels and the Department of Education's website. A website (SOFWeb) could be accessed across the state, nationally or internationally *via* Internet.

Digital resources

A joint venture called The Le@rning Federation, was developed as a major digital content project for Australian and New Zealand schools. The Le@rning Federation developed learning objects for schools as well as learning and content management systems. Some initiatives involved the development of content to meet the curriculum, professional development, and other educational priorities of education systems.

The Le@rning Federation, which was jointly managed by the Curriculum Corporation and education.au, began as a major digital content project for Australian and New Zealand schools. The Le@rning Federation developed specifications for educational soundness and new delivery systems such as web portals, learning management systems, and content management systems. A number of schools implemented major software packages to support these functions. The Le@rning Federation also developed a "Basic E-Learning Tool Set" to provide schools with the basic functionality for managing learning objectives, until comprehensive learning content management systems could be implemented within jurisdictions. State and territory education authorities also operated various initiatives for providing their schools with digital content. Some initiatives endeavoured to identify existing content and provide cost-effective access for schools. Others involved the development of content to meet the curriculum, professional development, and other educational priorities of education systems. Some schools established programs to support the development of new content by their own teachers.

ICT competencies of teachers and leaders

Data collected by state educational authorities suggest that around 90% of Australian teachers had at least basic competencies in ICT, and 50% of Australian teachers regarded their competency as "intermediate" or "advanced." In terms of the self-reported competencies of secondary school mathematics and science teachers Australian teachers compare favourably with other countries (Ainley, Eveleigh and O'Malley, 2009). Three quarters (76%) were confident that they could "produce a letter using a word-processing program", 58% were confident that they knew "which teaching/learning situations are suitable for ICT use" and 57% were confident that they "could find useful curriculum resources on the Internet". However

only 46% were confident that they could "produce presentations with simple animation functions", 42% were confident that they could "use ICT for monitoring students' progress and evaluating learning outcomes" and 37% were confident that they could "share knowledge and experiences with others in a discussion forum/user group on the Internet". Australian secondary school mathematics and science teachers expressed relatively high levels of confidence compared to their peers in other countries. Year 8 science teachers in Australia were not significantly different in ICT confidence from those in Singapore, Hong Kong, Alberta, Ontario, Chile, and Norway and were significantly more confident than other countries in the SITES survey. Year 8 mathematics teachers in Australia were not significantly different from those in Hong Kong, Singapore, Ontario, Alberta, Denmark, Chile and Norway but were significantly more confident than those in other countries (Ainley, Eveleigh and O'Malley, 2009). There was a positive association between there is a positive association between teacher confidence in using ICT and actual use of ICT in all countries (the median correlation coefficient was 0.3.

A national review of teaching and teacher education published in 2003 (Lee Dow, 2003) argued that ICT should be used widely in schools, and form part of the repertoire of all teachers. It recommended that teacher education programs prepare prospective teachers to use ICT as a knowledge management tool, and to support student learning. The review also argued that opportunities should be created for teachers to upgrade their ICT expertise. Australian school systems operate professional learning programs to extend the ICT competences of teachers. Some school systems use in-school professional learning models based on mentors. Others have developed various forms of "centres of excellence," that is, lighthouse or navigator schools, which serve as models of good practice and providers of professional development for teachers in surrounding schools. Some school systems reached agreement with local universities to ensure that pre-service ICT course content aligns with the needs and actual situations new teachers encounter in schools.

A review conducted by Downes and colleagues (2001) of a national project offering models of teacher professional development designed to facilitate integration of ICT into classroom practice identified barriers and critical success factors, and provided advice and recommendations for programs. The reviewers identified the principal barriers as funding, time, and a lack of linkages. They saw lack of funding as limiting the scope and form of teacher development, and identified time as one of the greatest challenges to effective professional development. They also pointed to a lack of connection and linkage between pre-service and in-service teacher education, in areas associated with ICT. Downes and her co-reviewers argued for ongoing support for the integration of ICT, and a portal for resources and research by extending the existing database website. In particular, they maintained that EdNA Online

(the Education Network Australia; see reference below to the website) should act as a professional development resource so as to support the integration of ICT in teaching and to facilitate connections between the professional development site and other EdNA Online-related sites. The reviewers argued also for the formation of a support network, linked to the online facility and targeted at professional development in relation to the integration of ICT in pedagogy. Finally, they emphasised that integration of ICT in education required targeting staff responsible for professional development programs, school leaders, in-school ICT coaches, leaders of professional associations, and teacher educators.

Digital education revolution

The federal government that was elected at the end of 2007 proposed a "digital educational revolution" as a centrepiece of its education platform. It aims to support change to teaching and learning in Australian schools. It will provide for new ICT equipment for all secondary schools with students in Years 9 to 12 and deploy high-speed broadband connections (fibre to the school) to Australian schools.

The DER intends to ensure that new and continuing teachers have access to training in the use of ICT that enables them to enrich student learning. It will require competency in ICT as a graduation requirement and ongoing progressive development of the capacity of existing teachers. It will provide online curriculum tools and resources that support the national curriculum.

It plans to enable parents to participate in their child's education through a parent portal and to provide assistance for schools in the deployment of ICT (AICTEC, 2008). There is a detailed strategic plan and roadmap to guide its implementation.

The stated goals of the DER include ensuring that students undertake stimulating learning activities that are supported by access to global information resources and tools for information processing, communication and collaboration. The DER intends that teachers should devise student-centric learning programs of learning based on established curriculum standards and supported by contemporary learning resources.

Monitoring and evaluation

Monitoring implementation

It is recognised that an evaluation and monitoring plan will be required to track progress in implementing the DER and to assess its effectiveness and efficiency. It is based on a documents developed by the council of ministers

entitles "Digital education – making change happen" (MCEETYA, 2008). This document provides guidance about how the integration of ICT in teaching, learning and administration can be gauged at the school and system level. It consists of ten elements that are each characterised through descriptors grouped in three levels: the developing school, the accomplished school and the leading school. The elements are:

- personalising and extending learning;
- enabling leadership;
- supporting professional learning;
- connecting learning beyond the school;
- improving assessment and reporting;
- developing, measuring and monitoring digital literacies;
- accessing and utilising student information;
- providing, accessing and managing teaching and learning resources;
- automating business processes; and
- providing reliable infrastructure.

In addition there is a plan to develop an overall evaluation strategy for the initiative as a whole.

Monitoring the impact on teaching and learning

ICT is applied in schools in a wide range of ways that reflect different purposes of learning. These include: using computers as an instructional delivery system to increase skills and knowledge; using technology as a tool for accessing resources, communication, analysis or simulations; using ICT to change teaching and learning processes in classrooms or school organisation; acquiring ICT knowledge and skills and understanding the role of ICT in society; developing ICT skills and knowledge for use in learning, work or more general social transactions (Kozma and McGhee, 2003). The need for the educational community to consider the impact of ICT on teaching and learning is undisputed and a variety of approaches has been adopted to investigate this. In Australia there has been a variety of studies that have investigated the impact of ICT on approaches to learning. These have included case studies of innovative practice (some of which use instruments as part of the study), quasi-experimental surveys of particular settings and some large-scale surveys.

Qualitative studies of innovative practice

Qualitative research approaches can provide detail about people, programs and events in a natural context and describe the interactions among them. Typically qualitative methods have been based on small numbers of cases and with little capacity to generalise findings from those cases to wider contexts. The Second Information Technology in Education Study Module 2 (SITES M2) sought to identify innovative educational practices using ICT (Kozma, 2003). The study was based on 174 case study reports drawn from 28 participating countries, each of which described an innovative use of technology to enhance pedagogy. Through mainly qualitative methods, the study examined the similarities across cases and across countries to identify patterns of innovative pedagogical practices. In SITES M2 rigorous procedures were enacted in terms of the selection of cases (using national panels or reference groups and clearly articulated criteria for selection), common instrumentation (in terms of who was interviewed in each case and the structure of the interview schedules), common data collection procedures (in terms of the duration and number of visits to each school) and the structure of each case report. Cluster analyses techniques were used integrate the findings from the large number of case reports.

In Australia five examples of innovative use of ICT were investigated (Ainley, Banks and Fleming, 2002). One of these involved using ICT as part of a study of the novel Chinese Cinderella in junior secondary school. Students used a wide variety of ICT tools including Access Tool Box, Microsoft Front Page, MediaGram and digital cameras to develop personal e-portfolios that they stored on the school's intranet. Another involved using Multi-media development tools to foster learning styles in a primary school. Curriculum topics were addressed through critical questions that students are asked to investigate. Students were organised into learning teams and the technologies used demonstrated an evolving sophistication. For example, in Grades 1/2, students made use of web sites to conduct research and email extensively. By Grades 6/7, students produced iMovies, preparing scripts and making and editing videos. The use of peer tutoring in ICT and a "skill register" meant that there was a great deal of interactive learning between students. A third example was the development of electronic distance education Virtual Schooling Service (VSS) to provide teaching in senior secondary school subjects where the numbers in a school (*e.g.* in a rural location) were not viable for conventional teaching. A Virtual Private Network linked government schools utilised use a range of software to provide course materials and conduct the learning sessions (NetMeeting Whiteboards, PowerPoint, interactive spreadsheets, and WebQuest). A fourth example involved an extensive integration of ICT into teaching programs. Students were grouped into four multi-age bands, and the curriculum was organised around themes. Teachers worked in teams and students were involved in collaborative

learning. Students share ideas about what they would like to learn within the themes and teachers take these ideas to flesh out the learning programs each term, assisted by two ICT experts at the school who suggest how ICT might best be incorporated into the proposed programs. Students work in groups but develop electronic portfolios of their own work that are the basis of assessment by teachers and used to showcase their work to parents. A fifth example used a process of sustained electronic communication (called the Virtual Bridge) as part of its orientation program for Grade 6 students from three small, remote feeder primary schools. The Virtual Bridge relies on a VPN for secure transmissions between students and the Grade 7 co-ordinator with the fundamental software being WebQuest.

Another example of systematic case studies was the *Innovation and Best Practice Project* (IBPP) that focused on innovation in 107 schools (Cuttance, 2001). Each had developed and implemented an innovation intended to improve learning outcomes for students. Schools were asked to research and assess the magnitude of the impact of the innovation on learning outcomes for different groups of students. Twenty schools provided opportunities for students to develop ICT-based skills and knowledge. Most provided evidence that the innovations were impacting on learning and learning outcomes beyond the standard curriculum outcomes. There was considerable variation in the way in which schools introduced ICT into their learning environments. Many innovations used computers and associated hardware to enhance the learning environment for students. Some used the Internet as a source of educational resources although bandwidth was a limitation. One school had developed on-line programs for students to study from home and another was producing multi-media learning resources. Five of the schools were based on notebook computers used by all students in the group.

Development of survey instruments

There have been several ventures that have involved the development and application of self-report survey instruments on a limited scale to study the impact of ICT on teaching and learning. One is the Classroom Computer Climate Survey (CCCS) which was developed by Robertson, Fluck, Webb, and Loechel (2004) to gauge ICT usage and practices in Tasmanian schools. The CCCS was distributed once a year for the years 2002-04 to teachers of Years 3, 5 and 7. The survey contained several categorical items, which gather information regarding teacher characteristics (*e.g.* estimations of own IT skills, professional development in IT), student characteristics (*e.g.* student use of IT at school, and access at home) and school characteristics (*e.g.* the IT resources possessed by the school). In addition, the survey contains two open-ended items: "How does the computer help students achieve their

learning outcomes across the curriculum?" and "How do you see computers affecting the future of classroom teaching?"

Another survey instrument is the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI): an 80-item inventory designed to assess classroom environments on ten dimensions. The TROFLEI built upon existing learning environment instrumentation through the use of the "What is happening in this class" (WIHIC) questionnaire as a basis for the development of a comprehensive instrument that includes a focus on technology and outcomes in secondary school classrooms. The TROFLEI has been validated with Tasmanian and Western Australian secondary school students (Dorman, Aldridge and Fraser, 2004).

The Learning with ICT: Measuring ICT Use in the Curriculum instrument (Jamieson Proctor, Burnett, Finger, and Watson, 2006) was used to investigate both the quantity and quality of student use of ICT for learning. The instrument contained 20 items, with response categories on a 4-point scale ranging from never to very often. Two sets of response categories are used to capture "current" and "preferred" teacher perceptions of ICT use by their students. The instrument was found to contain two strong factors: 14-items that define ICT as a tool for the development of ICT related skills and the enhancement of curriculum learning outcomes; and six items that define ICT as an integral component of reforms that change what students learn and how school is structured and organised. It has been found that male teachers report higher levels of confidence in using ICT with students for teaching and learning and students confident teachers use ICT more frequently to enhance the curriculum.

Records and logs of activities in teaching

Although much of the literature concerned with the impact of ICT on pedagogy is based on self-report questionnaire methods there other approaches to the study of pedagogy that make use of ICT and have been applied to the study of other aspects of pedagogy. These include the use of diaries or logs by students and or teachers and analysing the patterns that students use when working with computers.

One evaluation of a class program using laptop computers made extensive use of student diaries (M. Ainley *et al.*, 2000). The impact of using laptop computers was monitored in a variety of ways. Diary formats completed by the students were used to identify what students were thinking about what was happening in their schooling as they carried their laptop from class to class each day. The basic procedure involved taking a sample of student diary entries and developing codes that reflected the range of comments being made. The coding system was then applied to a variety of diary formats

to build up a picture of what the laptops and often computers in general meant for student learning. Using spreadsheets and some simple graphing functions it was then possible to display the overall results and make comparisons between groups of students. It concluded that a range of tool functions were served by having a laptop computer and that although there was variation in response among both students and teachers to the program and most of it was very positive. Students saw the computers as a tool for getting work done, and at the same time a tool that required them to learn how it operated (M. Ainley *et al.*, 2000)

Allan and Ainley (2002) focused on the use of ICT in teaching and learning in a specific field of study: Studies of Society and Environment (SOSE). The study involved 400 students and their teachers from 28 Grade 5 classes in ten Victorian primary schools. It used questionnaires completed by teachers and students at the beginning and end of the topics, "Time, Continuity and Change" or "Place and Space". In addition teachers completed a summary of their SOSE unit planners which provided details of learning objectives and outcomes, tools and resources, methods of assessment and the grouping configuration of the children for each of the activities. Each activity described in the teachers' SOSE unit planners was then coded according to the nature of use of ICT as a tool for learning, the knowledge and cognitive processing learning objectives underpinning the activity, and the domains of learning involved. In total, more than 500 activities were planned by the 28 teachers across the ten different schools in the study. On inspection of the unit planners, 58% of the teacher-planned activities incorporated some form of ICT use and just four per cent of all activities were conducted using ICT exclusively. Most commonly, teachers planned activities in the SOSE unit which used ICT to research for information and to process responses (*i.e.* work with ideas or construct response using information); 61% and 51% of activities respectively. Fewer activities involved presenting information (26%), learning ICT skills (19%), learning interactively (5%) and communicating (4%). The types of knowledge objective (following Anderson *et al.*'s taxonomy) used in the planning of SOSE activities (with or without using ICT) most commonly involved factual and conceptual knowledge. Very few procedural and metacognitive knowledge objectives were planned. In terms of planned objectives involving cognitive processing categories, remembering and understanding were most common. The results indicated that the potential of ICT to facilitate higher order thinking skills was not being fully utilised by these teachers.

M. Ainley and Hidi (2002) have investigated the dynamics of interest in student learning by focusing tasks that could occur in any classroom. Those tasks are presented in an interactive computer package that incorporates probes to monitor interest and emotions as they progress through the task and relate those to measures of learning at the conclusion of the task. Using the computer-based approach it has been possible to log students' feelings,

reactions and decisions across the course of the learning task. Sequences in the data record can be analysed using time logs that record students' paths through the task, levels of interest, choices of which material to access, and decisions about when to start writing an answer. It is evident that interactive software such as this provides great potential for educational research to probe more deeply the way students interact with tasks. These studies demonstrate the capacity of ICT to provide insights into the sequences that students follow when they complete a task.

Large scale surveys of teaching practice

Australia participated in SITES 2006 (Law, Pelgrum and Plomp, 2008) as a benchmarking country (Ainley, Eveleigh and O'Malley, 2009). The results indicated that Australian science and mathematics teachers are relatively high users of ICT compared to their counterparts in other countries. A higher percentage of Year 8 science teachers in Australian secondary schools used ICT in the past year than in most other countries surveyed (similar to Singapore, Hong Kong SAR, and Alberta). In addition, Australia was one of a group of countries in which a high percentage of Year 8 mathematics teachers used ICT (behind only Norway). Compared with their peers in other countries, Year 8 science and mathematics teachers in Australia are confident users of ICT. Computers in Australian secondary schools are less often located in classrooms (and more often in computer laboratories) than in countries such as Canada, Finland, Hong Kong and Norway. Australia is also a moderately high user of other ICT resources such as smart boards but is relatively low in terms of providing email facilities for students and data logging technologies for use in science classes. Despite their confidence in being able to use ICT, fewer Australian science and mathematics teachers than their peers in countries such as Chinese Taipei, Denmark, Estonia, Hong Kong, and Israel participate in ICT-related professional development. The data from SITES suggest that there remains much to be done in extending professional development for teachers but that this should not be at the level of introductory courses.

The use of ICT is greater when teachers have a higher level of or confidence in ICT, when teachers have participated in ICT-related professional development, and when there are fewer contextual obstacles (infrastructure, digital learning resources, access). In Australia, as in most countries, the percentage of teachers reporting ICT use is significantly higher for science teachers than for mathematics teachers. One inference to be drawn from this is that the subject (or discipline) context is an important aspect of the uptake of ICT in teaching. It may be that some subjects lend themselves more readily to the pedagogical use of ICT, that there are stronger traditions of innovation

in some subjects or that digital resources are more available in some subjects than others.

The most frequently cited obstacle to incorporating ICT in teaching was the time required to develop and implement activities. Another factor mentioned was the availability of digital learning resources in schools and student access to ICT tools. Infrastructure was seen an obstacle to ICT use by only about one quarter of Australian teachers and a similar number cited their own knowledge of using ICT in pedagogy as a limiting factor. These patterns were similar for science and mathematics teachers. School principals also indicated that a lack of time for teachers to use ICT was an obstacle to incorporating it in teaching. Three of the four top priorities nominated by school principals for enhancing the use of ICT in their schools, involved teachers: improving the ability of teachers to make good pedagogical use of ICT, improving the technical skills of teachers and increasing the number of teachers using ICT for teaching/learning purposes.

Evaluating progress in ICT literacy

In 2005, Australia began a cycle of thrice-yearly national surveys of the ICT literacy of students (Ainley and Fraillon, 2007; MCEETYA, 2007; MCEECDYA, 2010) using an innovative computer-based assessment. The Australian national assessment of ICT Literacy involved developing a computer-based assessment that combined automated skills assessments and the production of complex work products involving the evaluation and integration of information. The assessment instrument combined multiple item types within a single, consistently administered assessment. Within each assessment module students were asked multiple-choice questions to assess knowledge, to perform specific functions within simulations of software products to assess skill with common applications, to provide constructed responses to specific questions and to create work products using live applications. The work products, created under controlled, consistent conditions for every student, were evaluated using standardised rubrics by trained assessors. The assessment instrument consisted of seven thematic modules of which each student completed three. One reason for conducting the assessment with a number of modules was to ensure that the assessment instrument accessed what is common to the ICT construct across a sufficient breadth of authentic contexts.

Completing authentic tasks in real contexts was seen as fundamental to the design of this ICT literacy assessment. The assessment model defined a single variable, ICT literacy, which integrated three related strands. One strand involved identifying required information; formulating and executing a strategy to find information; making judgements about the integrity of the source and content of the information; and organising and storing

information for retrieval and reuse. The second strand involved: adapting and authoring information; making choices about the nature of the information product; reframing and expanding existing information to develop new understandings; and collaborating and communicating with others. A third strand included understanding the capacity of ICT to impact on individuals and society, and the consequent responsibility to use and communicate information ethically.

In the 2005 cycle the assessment was administered using sets of six networked laptop computers with all necessary software installed. Test administrators travelled to each school with the networked computers to manage the process. The assessment was conducted with approximately 7 400 students in 520 schools. The 2008 cycle made more extensive use of school computers with delivery being based on a plug-in server (68% of schools), connection to a server farm (19% of schools) and sets of networked computers brought to the school (14% of schools). It was conducted with just fewer than 11 000 students in just fewer than 600 schools.

In addition to conducting analyses of patterns among states and groups of students using ICT Literacy scale scores a set of six proficiency levels were defined as shown in Table 4.1. The boundary between level 2 and level 3 was defined as the proficient standard for students in Grade 6 and between level 3 and level 4 was defined as the proficient standard for students in Grade 10. The results indicated an improvement between 2005 and 2006 for Grade 6 students and a (not statistically significant) tendency to improve for Grade 10 students.

ICT literacy was associated with socioeconomic background and indigenous status. ICT literacy also differed among geographic locations: metropolitan students to recorded higher ICT literacy scores than students in provincial areas who, in turn recorded higher scores than those in remote areas. It was also noted that there was an increase in the use of computers at home and at school and this increase may well be a reason for the increased level of ICT literacy. Social communication was the group of most frequently used applications followed by entertainment and school utilities with computer technology being the least frequently used group of applications.

Table 4.1. **ICT literacy proficiency level descriptions and percentage distributions, 2005 and 2008**

Level	Proficiency level description	% Grade 6		% Grade 10	
		2005	2008	2005	2008
6	Students working at level 6 create information products that show evidence of technical proficiency, and careful planning and review. They use software features to organise information and to synthesise and represent data as integrated complete information products. They design information products consistent with the conventions of specific communication modes and audiences and use available software features to enhance the communicative effect of their work.	0	0	0	1
5	Students working at level 5 evaluate the credibility of information from electronic sources and select the most relevant information to use for a specific communicative purpose. They create information products that show evidence of planning and technical competence. They use software features to reshape and present information graphically consistent with presentation conventions. They design information products that combine different elements and accurately represent their source data. They use available software features to enhance the appearance of their information products.	0	1	12	18
4	Students working at level 4 generate well targeted searches for electronic information sources and select relevant information from within sources to meet a specific purpose. They create information products with simple linear structures and use software commands to edit and reformat information products in ways that demonstrate some consideration of audience and communicative purpose. They recognise situations in which ICT misuse may occur and explain how specific protocols can prevent this.	8	15	49	47
3	Students working at level 3 generate simple general search questions and select the best information source to meet a specific purpose. They retrieve information from given electronic sources to answer specific, concrete questions. They assemble information in a provided simple linear order to create information products. They use conventionally recognised software commands to edit and reformat information products. They recognise common examples in which ICT misuse may occur and suggest ways of avoiding them.	41	41	32	26
2	Students working at level 2 locate simple, explicit information from within a given electronic source. They add content to and make simple changes to existing information products when instructed. They edit information products to create products that show limited consistency of design and information management. They recognise and identify basic ICT electronic security and health and safety usage issues and practices.	39	30	6	7
1	Students working at level 1 perform basic tasks using computers and software. They implement the most commonly used file management and software commands when instructed. They recognise the most commonly used ICT terminology and functions.	13	13	0	1

Source: MCEECDYA (2010).

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Chapter 5

Extending and scaling technology-based innovations through research

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This chapter examines the question of 21st century skills through the prism of a case study on Singapore. Certainly, this case is quite particular in many respects, including its emphasis on the design, implementation and evaluation of national master plans. The support to technology-based innovations, as well as their monitoring and assessment, have been playing an important role in these plans. This contribution discusses the different ways in which practitioners, researchers and policy makers have been involved in the process of documenting successful innovations and planning for scaling up. The authors suggest that careful attention should be paid to the translation process from the initiation of innovation to the implementation of innovation.

Introduction

Traditionally, the extending and scaling of research innovations in education has been viewed through the lens of multiplication (increasing numbers) and spreading (increasing areal reach). In *Diffusion of Innovations* (Rogers, 1964), innovation is defined as any new idea, practice or object, and innovation diffusion is measured in terms of the number of innovation adopters over temporal, social and spatial dimensions. Such a view of innovation-scaling is therefore product-oriented, in that the deliverables (performance indicators) of successful "scaling" are defined according to strict numeric constructs (*e.g.* the number of teachers, the number of schools, the number of school clusters, etc). We would extend Rogers' definition of innovation that the innovation idea should *add value* to the current *status quo*, and in this case, of the learning and educational process as mediated by technology.

Another limitation of product-oriented innovation-scaling theories such as "Diffusion of Innovations" is that the process (rather than factors) in which pre-adopters make transitions through their participatory involvements in the community has not generally been the focus of investigation. An often implicit assumption of this view is that these innovation "products" are replicable *en masse* without undergoing (and, without the need to undergo) significant change from the original.

Such a view of scaling stems from a twentieth-century Fordist-production paradigm (as applied to traditional notions of Instructional Design), and there are numerous examples of such an interpretation which can be cited from within the Singapore school system. Such views are challenged by alternative paradigms such as "Communities of Practice", in which social and contextual dimensions and people-activity interdependencies are foregrounded, thus supporting a process-oriented perspective. Such processes are enacted through shared codes of conduct, histories and cultures (Wenger, 1998).

The purpose of this paper is to further our understanding of a process-oriented and situative view of extending and scaling innovations, recognising the contextual fidelity of each translative iteration. Moreover, we hope to develop a locally oriented translation-scaling framework for extending technological innovations. We worked on the premise that an innovation with a view to extension or scaling would be premised on the assumption that the normative population through which the "spread" is intended is generally not ready for the innovation. Hence the need for translation and reaching out to the targeted population.

It is our contention that 21st century learning and literacies demand a fundamental rethinking of such a framing of innovation-scaling. We echo Latour (1993) in proposing a more nuanced, situative view of innovation-scaling – one which explicitly foregrounds the local contextual factors and

interplays within which all iterations from the original are embedded. To elaborate, a shift needs to be made from the strict multiplicative metaphor to what we term a "resemblance" metaphor. We argue that inherent in such a resemblance metaphor is the explicit recognition that the extension and scaling of innovations arising from education-research is just as much a process as it is a product; and because innovation-scaling is a process, it is by definition not processes to be replicated, but instead to be re-created/re-instantiated/re-enacted. Such instantiations and enactments take place in the milieu of the products of the innovation, namely artefacts and boundary objects. The latter form the substrate from which the dialectical interactions between product, process and participant-practitioner are lived and therefore reified. Going forward, it is our strong conviction that such a framing of the extension and scaling of innovations will inform the direction of many education-research interventions in Singapore. Hence, subsequent re-instantiations from the original are not reproductions but re-creations which have resemblances to the original. We posit that such a view is critical for scaling technological innovations in particular because the affordances inherent in supporting pedagogy as recreated in subsequent instantiations are *inquiry* inclined. Teachers have to appropriate not just the products but re-contextualise the (inquiry) processes – usually related to curricular and assessment resources – in their respective settings, and with a view to being consistent to the conceptual underpinnings of the original innovation.

In the translation literature, it is generally accepted that there are two broad thrusts of translation (Institute of Medicine's Clinical Research Roundtable, Sung *et al.*, 2003). These are, namely, translational research (T1) and translation research (T2). T1 refers to deductively-derived research interventions, which have been enacted within relatively homogenous and resource-rich contexts. T2 refers to the dissemination, implementation, and diffusion of T1 research into community-practice and policy (*e.g.* Narayan *et al.*, 2000 and Schillinger, 2007). In turn, dissemination refers to how the targeted distribution of information and intervention *materials* can be successfully executed, implementation can be thought of as referring to the implementation of content (the interpretation by practitioners of the research evidence and of the codified intervention) within a given (political/professional/socio-economic/organisational/attitudinal) context, through the process of enacting and engaging in strategies for change in (and, and) management practices. As for diffusion, the lens is turned on the *factors* for successful adoption of the intervention which results in widespread use by the target population. Such "successful adoption" can be further analysed in terms of the uptake of the practice and/or innovation, as well as in terms of the penetration of broad-scale recommendations through dissemination.

Unlike translation science, diffusion research can trace its roots into the mid twentieth century. Kroeber (1940) and Hägerstrand (1967) have written

extensively on the matter, and of particular relevance to the present discussion is the reminder that diffusion need not necessarily be assumed to originate continually from a single, authoritative source (expansion diffusion), but can also take place through other models such as through contagion and hierarchy. In this regard, consideration should therefore be placed on the dispositions of the change agents, particularly according to Rogers's (1964) characterisations of innovators, early adopters, the early majority, the late majority and laggards.

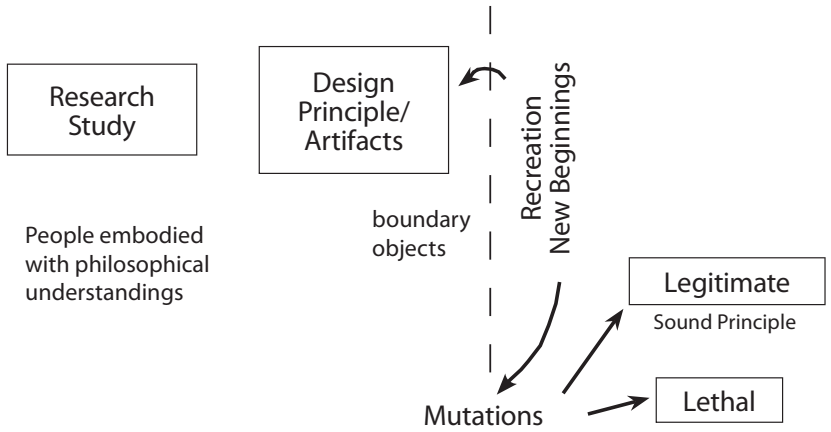
What might some key performance indicators of T2 be? In the translation literature, Glasgow's (1999) articulation of the so-called RE-AIM framework has been frequently cited and speaks authoritatively to this question. The RE-AIM framework was explicitly designed from the outset to be an evaluation framework for translation. It describes five dimensions, which operate at either (or both) the individual and organisational levels. At the individual level, the success of any given translation effort can be evaluated against the criteria of *Reach* (into members of the target population), *Effectiveness* (ability of the intervention to do more good than harm in a real-world setting (contrasted with *Efficacy*)), and *Maintenance* (in individuals over time). At the organisational level, the success of any given translation effort can be evaluated against the criteria of *Adoption* (by target settings and target institutions), Implementation (consistency across programme components and members in terms of the aforementioned aspects of content, context and process) and *Maintenance* (in populations over time; implicit in this notion of maintenance are both sustainability of the innovation/intervention and the adaptation thereof). The RE-AIM framework is extremely helpful because it is accommodative enough to provide policy makers and programme evaluators with an evaluative structure against which to compare (in a fairly objective manner) potentially very different interventions. Potentially, weights could be applied to the five dimensions in order to reflect the priorities and imperatives of policy and funding. To the present author's mind, this point cannot be over-emphasised.

A way forward

Summarising from the above issues, a process-oriented translation framework does not preclude the role of products and other codified forms of reifications. Based on our experiences in Singapore, innovations – be they pedagogical and/or technological – begin usually as research initiatives/projects. These research efforts (from the Learning Sciences Lab, Singapore) can be broadly construed as T1 efforts. Many of the technology-mediated research projects from the Learning Sciences Lab (Singapore) adopt design-based research methodologies, implying that researchers and practitioners in school-based innovations co-construct the agenda of the entire intervention. Arising from these interventions, there is an emergent recognition that for

T2 to occur, people-preparation and foundational tenets described through a sufficiently well-specified and articulated set of codifications in the form of design principles, norms, and procedures are necessary (see Figure 5.1). Alongside these codified representations of design principles, technological innovations include prototypes (products). It is acknowledged that such prototypes run the risk of being extended or scaled without the necessary understandings of how they are to be appropriated in ways that deeply embrace the philosophical underpinnings of the design principles arising from their respective theories of action. It is an understandable apprehension of researchers who purport process-orientations that their codified products get lethally mutated from their original intentions. Worse still is the possible ex-appropriation (through questionable legal means and motives) of products in ways that undermine the intellectual property rights of the originators. How might some of these issues be reconciled, particularly the thorny issue of managing mutations?

Figure 5.1. **Framework for translation and extension/scaling innovations**



Consistent with the re-creation and "resemblance" metaphor, rather than re-production, we conjecture that mutations are inevitable; and indeed desirable and healthy. To be philosophically situative, every recontextualisation effort cannot be identical to previous instantiations since any social context is chaotic (Poincaré, 1890) and unpredictable. The issue is hence not about mutations *per se*, but is instead the extent to which these mutations might be considered lethal! To probe more deeply into this notion of "lethality", lethality is often considered relative to the original as a frame of reference. We

would however wish to suggest that since mutations are inevitable, the criteria for judging mutations should be whether they are legitimate rather than lethal. By legitimate, we suggest that the mutations are within sound learning principles broadly specified rather than very specific design principles nearly consistent with the original design specifications of the research project.

Central to the translation design of our framework (see Figure 5.1) are the principles of:

1. embodiment
2. reification/codification
3. dialogue
4. brokering

By embodiment we refer to the intentional design for people (researchers, practitioners, brokers) to take an active part in the actual social participation of the research project and the subsequent instantiations. Through embodiment, participants develop both explicit reifiable knowledge and the implicit understandings that may not be made explicit through language (a notion similar to the map not being the territory).

Consistent with our design research methodologies, we acknowledge the need to describe a set of codified design principles which arise from the research study. The specification-details vary across research projects but a general rule of thumb might be that someone expressing interest in applying the design principles could be confident in staying true to them when complemented with exemplars (such as, but not limited to, video cases), and curricular and assessment resources. Importantly, to avoid lethal mutations, the people who take these products forward need to have a sensible and consistent understanding of the philosophical underpinnings of the original project. This cannot be achieved through traditional notions of "sharing sessions", but should instead be structured through exchange programmes/mentorship programmes.

Such programmes segue well into "dialogue", by which is meant the need for participants, whether in the research project or in subsequent instantiations, to constantly dialogue around the reifications constructed by the research project and in the translation efforts. Through the process of dialogue, misconceptions can be explicated and understandings advanced. Participants newer to the process can also be gradually enculturated through dialogue between different members of the research-translation community (researchers, practitioners, brokers). The key thrust is in involving stakeholders from the start with a view to establishing shared language and understandings through boundary objects (such as design artefacts). Since translation must be locally relevant, outcomes must be important to practitioners, must be seen as feasible, and as addressing issues of local concern (Glasgow and Emmons, 2007).

Finally, brokers are those who mediate and enable others who are able to deeply articulate the goals and philosophies of the original research project (on the one hand) and the subsequent uptake by individuals who appropriate the design principles and resources (on the other). Brokering is needed to bring diverse groups of people together who – because of their differing philosophical trajectories – may not necessarily be readily thought of by the other as holding potentially similar levels of specificity with regards their respective epistemological stances.

From research projects to extension and scaling

To reiterate, our starting point is research projects. This seeding process of research projects is an intentional stage where different interventions are trialled in schools. Importantly, it is recognised that design-based research involves practitioners at an early stage. Care needs to be taken that such practitioner-involvement is not enacted in a monologic way, but through true dialogue arising from mutual trust and respect. Even with embedded translation and the design principles reified, there is still a need to extend the dialogic conversations to subsequent stakeholders on the potential challenges and issues (such as IP rights) so as to build towards future extension and scaling. In the extension and scaling efforts, deliberate efforts should be made towards seeding for a research-practice community as a structure to engage the participants with the various context-instantiations. All stakeholders bring to the table their respective disciplinary understandings and values. Brokers are present to mediate these axiologies such that they are mutually honoured by all parties.

The projects conducted by the researchers at the Learning Sciences Lab usually adopt the Design Research methodology (van den Akker, Gravemeijer, McKenney and Nieveen, 2006). Inherent in this methodology is the joint partnership in the research design and implementation with practitioners (*e.g.* teachers and school leaders) throughout the process. Teachers co-design the tasks, curricular, and assessment resources together with researchers, and the overall design process is iterative and refined as it is implemented with students. Through a collaborative journey, stakeholders co-create the innovation by designing the process in an iterative, evaluative, and reflective fashion through dialogue and experimentation. The entire process is "researched" through constant monitoring and evaluation.

In the same vein, the principles inherent in design research are appropriated into our proposal of the three-staged process of translating research into practice. Early adopters are sought and enculturated, including policy makers who can influence the diffusion process. Design specifications from the research project(s) are further tested and elaborated in (more homogeneous) settings where the designs are to be potentially implemented. Dialogue

is the key strategy to enable new stakeholders to understand the conceptual underpinnings of the innovation. The entire three-stage translation process is "researched" – monitored and evaluated in an iterative fashion. Before the third stage of "extension and scaling", lessons need to be learned by a clear articulation of design principles and establishment of the boundaries of immutable features of the intervention – that is where the design specifications cannot be compromised. In other words, the stakeholders involved need to clearly understand the extent through which mutations are legitimate, beyond which lethal mutations will likely occur.

As an example, one of the flagship projects from the Learning Sciences Lab is the NRF-funded citizenship education videogame *Space Station Leonis*. This game was piloted in schools during 2007, and extended in 2008. The theoretical foundation for the game-enactment is Gee's (2007) notions of projective identity and dialectical phronesis, which itself has its roots in Aristotlean noesism. The game allows players to adopt role performances and in the (inquiry) process make decisions. These games are not the instructional games where content learning is the focus, but rather are more consistent to the MMPOGs which are popular among youths, and where players experience embodiment as avatars.

The *Leonis* programme has now run its course in terms of the initial funding, and is presently being considered for release to schools in Singapore. Because of its inherently axiologic design trajectory, it is acknowledged that the *Leonis* programme may not necessarily be easily appropriated in to a high degree of fidelity to its original design parameters by practitioners who do not share a strong Bakhtinian/Losskyian philosophical tradition. At the same time, other voices in this heteroglossic contestation about translating the *Leonis* programme into contexts and settings which it was not originally designed for (such as the primary school environment) have resulted in programmatic offshoots-in-development *inspired by* (but having no affiliation with) the *Leonis* programme which have attempted to re-contextualise what are perceived to be its key design principles into a socio-cultural developmental milieu for younger learners.

In terms of the three-stage framework proposed above, this deliberate structuring for extension and scaling is a necessary follow-through upon the completion of the initial research project. In this stage, issues of licensing and IP rights have to be seriously considered. Deliberate plans should be made to expand the pool of stakeholders in order to complement efforts to foster a deeper sense of Bakhtinian dialogism as a lens for critical inquiry.

In the example of the *Leonis* programme, seeding a community in game-based learning would be needed. Key community members would include research faculty, teachers from participating schools, and officers from the local ministry of education involved in assisting schools with game-based pedagogies.

Table 5.2. **Three stages from research projects to extension and scaling**

Stages	Tenets	Key translation issues
Seeding research projects (T1)	Research projects need to perturb the *status quo* of current pedagogical and learning practices	– How do we identify research projects which have the potentials for extension and scaling? – What are the criteria?
	Researchers engage with practitioners in co-designs and implementations throughout	– How do we design research projects with translation, extension and scaling in view?
Deliberate structuring for extension and scaling	Before extension and scaling can take place, there needs to be an intentional phase needed to dialogue and think through issues that would surface in extension and scaling efforts. These issues include: IP matters, adequate preparation of the people involved in extension and scaling, testing out the adequacy of the specifications of design principles and related resources, and others.	– How can research designs be extended out and scaled up in different contextual situations? – What or where are the boundaries beyond which the design cannot be compromised? – What are the key strategies for re-iterating?
	Seeding a community of stakeholders who understands the translation efforts	– What are the inter-relating factors leading to extension and scaling? – What are considerations need to prepare for extension and scaling? – What product issues need to be put in place? – What process preparations are needed? – What criteria do we employ to determine readiness for extension and/or scaling? – Who should these initial stakeholders be (*e.g.* innovators) in the seeding process of the community?
Extension and scaling (T2)	Scaling begins when translation issues have been piloted and design specifications tested and diverse populations would likely interpret these resources in appropriate ways.	– How can we engage in extensions and scalings which are legitimate?
	Sustaining the community	– How do we evaluate the successful efforts in extension and scaling (RE-AIM)? – What do we do with lethal mutations? – How do we plan for sustaining the community? – Who (*e.g.* early adopters)? Should we be reaching out to in order to enthuse new membership into the community?

Most of the research projects undertaken at the Learning Sciences Lab have pedagogical innovations that can be characterised as "distant from current school practice". Another project referred to as knowledge building community attempts to enculturate a knowledge building epistemology to the science inquiry process where students think like scientists. Although students in Singapore do generally well for science national stakes examinations, knowledge building is only nascent to school practices. For knowledge building to scale up, teachers' epistemology of science needs to be changed to one of inquiry and meaning making.

Gradually changing current school practices is key to the translation process and this is indeed a daunting challenge. One of the key strategies is to show through research evidence that students do not necessarily perform worse in the traditional exams although they spend a considerable amount of time in these inquiry-based innovations. Getting the support of parents in these efforts has also been useful to the infusion of such innovations.

Conclusions

This paper has been framed as a positional statement of present understandings of translation, extension and scaling, as held by its authors, in their respective institutional contexts. It is acknowledged that the nascent nature of translation science renders the expectation of any definitive conclusions both unhelpful and unrealistic. Instead it is hoped that the framework and ideas presented here will form a common substrate upon which conversations about these very issues may emerge and be sustained.

By way of a summary and less by way of a conclusion therefore, we believe that the key to successful translation is people. Effective strategies to enculturate people include:

- Involving stakeholders in co-analysis and co-design from the start.
  - iterations of the design-development programme;
  - planning for curricular enactments;
  - planning for professional development;
  - working towards mutual benefit for all stakeholders (including cognizance of local issues and concerns); and
  - building towards mutual trust and respect (no single member should have ownership of the data, nor of its interpretation.

- Establishing shared language and understandings through boundary objects (design artefacts).
  - clear articulation of design principles; and
  - clear establishment of the boundaries of immutable features of the intervention (addressing "flexibility versus fidelity" through "rigour without rigidity").
- Seeding and incubating a community of researchers, practitioners and brokers to augment translation.
  - building on strengths and resources within the community (Israel *et al.*, 1998); and
  - bearing in mind that while the community may be a global collective, translation always needs to be locally relevant, by which is meant that outcomes must be important to practitioners and must be seen as feasible and addressing issues of local concern (Glasgow and Emmons, 2007).

Taken together, it is envisaged that the preceding strategies will go some way towards illuminating what is as yet an amorphous and evolving ecological space which draws its impetus for growth from the research-practice nexus. It is also hoped that this paper builds on Rogers's (1964) work by drawing attention to the product-process dialectic, foregrounding the latter while not discounting the former. In this way, we are informed by the increasing number of post-modern socio-cultural milieux in which scaling is far more a trans-contextual phenomenon than what was afforded to Rogers in the 1960s.

We have chosen to stress the importance of people and stakeholders as a key dimension in successful translation efforts. By arguing for a community framework to augment translation efforts, we have proposed a social participatory process complementing the traditional product-oriented scaling models. We see this as another significant contribution of this paper to the literature. We frame such a community as central to the success of re-creating resemblances and legitimate mutations relative to the original research innovation.

Finally, consistent to the principles of the design research methodology, studying and refining the translation trajectory is our process-oriented approach for monitoring and evaluating the research innovations in a systemic fashion. Instead of a product-oriented scaling emphasis which usually measures quantitative outcomes of technological adoption, we design for a systemic change process involving qualitative measure of change and outcomes. We argue for such a "situative" need in order to complement the many qualitative studies measuring spread in school systems but offer little

understanding of the process and nature of change involved. Consistent to the situative stance, our process-oriented and contextually sensitive design methodology for translation enables knowledge and understandings to be socially constructed within the community of stakeholders. Through such a lived experience, knowledge is "managed" and understandings deepened through the production of artefacts and mediated by dialogue.

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Part III

Promising Avenues For Research

Chapter 6

The third lever: innovative teaching and learning research to support educational change at the system level

Maria Langworthy (Langworthy Research),
Linda Shear and Barbara Means (SRI International)

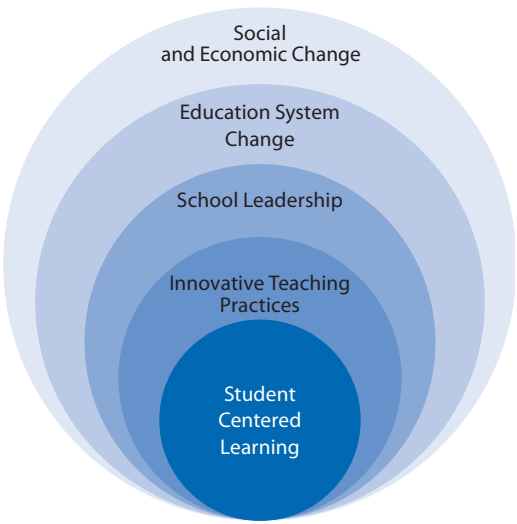
The following chapter introduces an important international and comparative research effort to develop and contribute a set of tools to measure educators' adoption of innovative teaching practices. It looks at the degree to which those practices provide students with learning experiences that promote the skills they will need to live and work in the 21st century. Still in its initial phase, this major research effort represents an important challenge to existing assumptions about the lack of connection between teachers' innovation practices involving technology and students' achievements.

Introduction

Today's ICT-enabled global economy requires a much higher percentage of workers with advanced skills and learning capacities (Partnership for 21st Century Skills, 2004; Scheuermann and Pedró, 2009). Countries that do not develop workers with the skills and capacities to meet new labour market dynamics risk falling behind (Wagner, 2008). Throughout history, education systems have evolved in relation to changes in the means of production and the needs of labour markets for different distributions of skills and knowledge (Cole, 2010). The challenges that confront education leaders today are similarly propelled by economic and social shifts that demand more individuals achieve more advanced skills and learning capacities than ever before.

To address these challenges, there is growing consensus on the need to dramatically rethink how learning happens inside and outside schools. Much of this debate is centred on the potential for technology to play a more direct and central role in student-centred learning (Mitra *et al.*, 2005; Christensen *et al.*, 2008). Researchers and advocates suggest that the role of schools and of educators should change to meet the needs of new millennium learners today (Pedró, 2009; Dede, 2010) and to build on what has been learned through research about how people learn (Bransford *et al.*, 1999). Policy makers and many education system leaders have supported these directions through their budget allocations (*i.e.* significant investments in ICT) and by supporting professional development programs for educators aimed at using ICT in the classroom. However, these two levers of support do not appear to be enough

Figure 6.1. **Educational transformation model**



to compel the widespread educational change and innovation needed to transform *the majority* of schools and teachers. In most countries and education systems around the world, real change in education is still happening in only a very few cases, driven by heroic individuals who innovate their teaching practices and their schools in relative isolation. Further change is required at the system level to enable more widespread change in how education is conceived and realised in the 21st century. Education leaders and researchers are beginning to reflect on what other kinds of levers at the system level will enable the broad majority of schools and educators to implement change in the near term (DeLorenzo *et al.*, 2008; Fullan, 2010).

Educational practice measures represent a third lever at the system level. The need for new student educational achievement assessments that measure the new types of skills and capacities needed in the 21st century has become well understood. Extensive work and significant progress is already underway in this area, though adoption of new forms of student assessment may well take many years (Brinkley *et al.*, 2010). However, less attention has been focused on measures that can be used to provide feedback to schools and educators, particularly measures of innovative teaching practices that support students' acquisition of 21st century skills.

This paper describes a new international research project called Innovative Teaching and Learning (ITL) Research which aims to develop and contribute a set of tools to measure educators' adoption of innovative teaching practices and the degree to which those practices provide students with learning experiences that promote the skills they will need to live and work in the 21st century. The ITL Research project (*www.itlresearch.com*) studies what works at the system, school, educator, classroom and student levels. Through this investigation, the project is developing and testing research methods that measure innovative teaching practices and students' 21st century skills. These methods will be contributed to the public domain, potentially providing the basis of several new key indicators for ICT in education and allowing more consistent evaluations and comparable data internationally of progress in effectively integrating ICT into teaching and learning by educational systems and by individual schools. The paper begins with a description the project's background, design and methods. It then describes the initial policy implications of this project. Throughout the discussion, a few of the findings from the pilot year data collection are described, but the full report of the pilot year analysis will be published separately.

ITL Research began with pilot work in Finland, Indonesia, Russia and Senegal in 2009, and it is expanding to additional countries for the period from 2010 to 2012. The project will provide education policy makers with both new measurement tools and descriptions of how technology can be integrated into teaching and learning to achieve desired student learning outcomes. Microsoft's Partners in Learning has provided the initial sponsorship for ITL

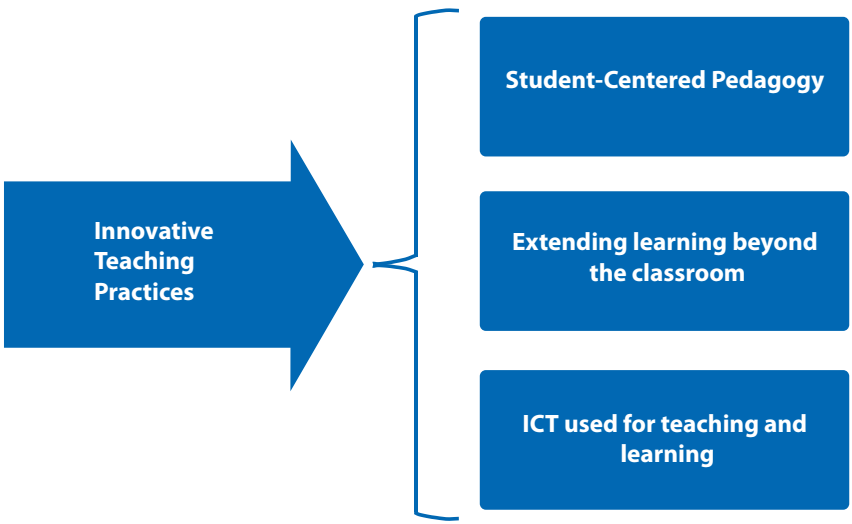
Research, which uses a multi-stakeholder partnership model including each participating country's education policy makers and highly respected local research organisations as well as a group of international advisors.

ITL research background

Educational change is complex and takes place within existing complex ecosystems of influences that include national policies and programs, support from local communities, school-specific cultures and leadership, and the inexhaustible diversity of individual educators and learners. From an investigation standpoint, ITL Research takes a broad look at education ecosystems, seeking to contribute to the current understanding of how effective transformation of teaching and learning supported by technology is taking place. The project is fundamentally focused on the need to measure system and school elements in relation to what happens in the classroom. It begins with this premise that teaching and learning take place within highly complex ecosystems where causality for learning outcomes is unlikely to lie in a single or even a small set of variables. ITL Research examines the patterns of relationships between many variables that have been identified as related to learning outcomes in previous research (see logic model, below).

Within educational ecosystems, ITL's core focus of investigation is on "Innovative Teaching Practices" that provide students with learning experiences that promote 21st century skills. This focus on teaching practices is

Figure 6.2. **Innovative Teaching Practices**



informed by many studies that suggest having technology in schools does not by itself lead to changes in learning outcomes (Dynarski *et al.*, 2007). First, having technology available does not mean that educators will use it or meaningfully integrate it in teaching and learning (Cuban, Kirkpatrick and Peck, 2001; Russell, Bebell, O'Dwyer and O'Connor, 2003). Second, a significant body of research shows that *how technology is used* can determine whether or not its use affects learning outcomes (Wenglinsky, 2005). Third, ITL Research focuses on educators and their teaching practices as a key factor in influencing learning outcomes based on research that demonstrates the teacher's effect (Darling-Hammond, L., 2010).

The construct of "Innovative Teaching Practices" was developed based on these ideas and an extensive review of existing literature and previous research, including leading multinational studies such as the Second Information Technology in Education Study (SITES; Law, Pelgrum and Plomp, 2006) and the Programme for International Student Assessment (PISA; OECD, 2006); frameworks for 21st century teaching and learning (*e.g.* UNESCO, 2008; Government of South Australia, 2008; ISTE, 2007, 2008); and research on specific constructs related to teaching practices that are associated with positive student outcomes (*e.g.* Bryk, Camburn and Louis, 1999; Groff and Mouza, 2008).

The construct of "Innovative Teaching Practices" in the ITL model includes dimensions beyond technology use that speak to the larger pedagogical philosophies that inform individual educators' decisions. More specifically, "Innovative Teaching Practices" are characterised by student-centred pedagogy, learning opportunities that transcend the school walls, and the integration of ICT into teaching and learning. These dimensions are explained in more detail below.

ITL research design

ITL Research will conduct research for three years, developing parallel country case studies for a deep investigation of the national and school-level factors that shape teaching practices within particular country contexts. At the global level, ITL Research will look across the country cases to provide information and informed recommendations on how to most effectively reshape teaching and learning for students' acquisition of 21st century skills.

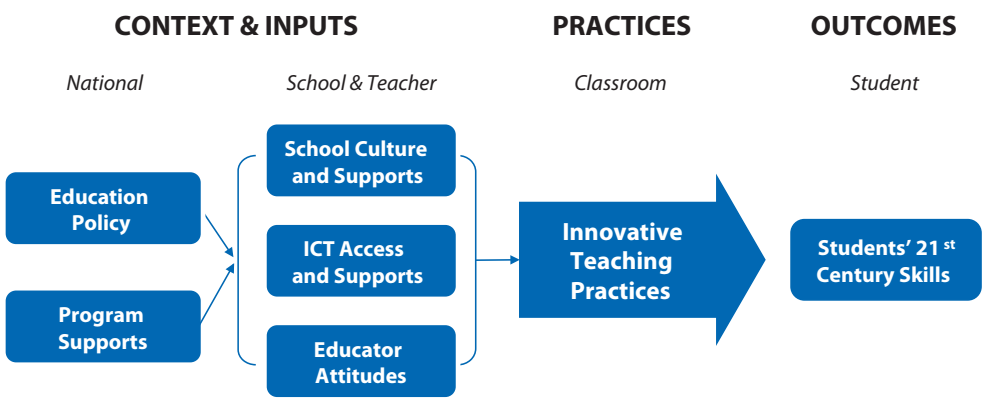
In 2009-10, the pilot year of ITL Research was carried out in four participating countries (Finland, Indonesia, Russia and Senegal) that were selected in part to reflect the range of economic, cultural and educational conditions around the world. In 2010, Australia, Mexico, the United Kingdom and the United States are joining the study.

ITL Research's Global research questions are as follows:

1. To what extent do innovative teaching practices contribute to 21st century learning outcomes?[1]
2. What school-level conditions contribute to innovative teaching practices?
3. How are national or regional program supports associated with increases in innovative teaching practices?[2]

These questions contributed to the logic model shown in Figure 6.3. While this model is not a comprehensive picture of all of the influences that shape education ecosystems, it represents a range of key constructs and dimensions that research and policy directions suggest are particularly important, and it seeks to look at these dimensions in relation to one another from a systems perspective.

Figure 6.3. **ITL research logic model**



Each of these constructs and dimensions carries specific descriptions and meanings that are used throughout the ITL Research program and methods:

- ***Innovative teaching practices*** are the focal point of the investigation. As noted above, the construct of innovative teaching practices is defined as including three primary dimensions:
  - *Student-centred pedagogies.* In the ITL model, student-centred pedagogies include practices of teaching and learning that are project-based, collaborative, foster knowledge building, require self-regulation and assessment, and are both personalised

(allowing for student choice and relevance to the individual student) and individualised (allowing students to work at their own pace and according to their particular learning needs). Each of these elements has a strong base of prior research linking it to positive outcomes for students in terms of development of 21st century skills (for example, Bransford, Brown and Cocking, 1999; Darling-Hammond *et al.*, 2008).

- *Extension of learning outside the classroom.* This construct refers to learning activities that reflect the nature of high-performing work groups in the 21st century. Learning activities extend beyond the traditional boundaries of the classroom, for example, by including individuals from beyond the classroom community (for example, parents, experts, community members), by providing opportunities for 24/7 learning (for example, research outside the classroom), fostering cross-disciplinary connections, and promoting global awareness and cultural understanding.
- *ICT integration in teaching and learning.* This construct relates to uses of technology by teachers and by students. Because the impact of information and communication technologies (ICT) can vary widely depending on its pedagogical application (Myndigheten For Skölutveckling, 2008), this construct includes a focus on *how* ICT is used and not simply *whether* it is used. For example, ITL distinguishes in its measures between basic or rote use of technology and higher-level technology use that takes better advantage of the potential technology offers for learning.

• Innovative teaching practices are shaped by a host of ***school and educator-level factors***. The model focuses on three overarching constructs:

- *School culture and supports* that shape teaching practice. For example, research has shown that teacher *communities of practice* can provide a powerful force for change (Little, 2006) and that *school leadership* is a critical factor in providing the context for innovative practices to emerge and extend throughout a school (Shear *et al.*, 2010).
- *ICT access and support*, including such factors as location, availability, and functionality of ICT tools. Educators cite lack of technology access and support as a primary barrier to the integration of ICT in teaching and learning (Law, Pelgrum and Plomp, 2006).
- *Educator attitudes* shape educational reform in powerful ways. In ITL Research, this construct includes teacher beliefs about

teaching and learning (for example, their beliefs about new *vs.* traditional pedagogies; Becker and Reil, 2000), teacher motivation and self-efficacy (Gibson and Dembo,1984), and teacher attitudes towards ICT's value in teaching and learning.

- School and classroom factors operate in the context of ***national and regional education systems*** (including structure, policy, vision, and capacity) and *program supports* (such as professional development) which may be available through programs sponsored by government, NGOs, or the private sector.
- Finally**, *students' 21st century skills*** include broad skills that are seen as important goals of innovative teaching practices. The ITL Research model characterises these skills as knowledge building, problem-solving and innovation, skilled communication, collaboration, self-regulation, and use of ICT for learning.

These key constructs are described in more detail in the ITL Research Design (available at *www.itlresearch.com*), including specific definitions that operationalise each of the constructs for the purposes of ITL Research.

ITL Research uses a global research design with common methods that are carried out by country research teams. SRI International is the global research partner responsible for overall research design, methods development, data collection co-ordination, and global results synthesis. This role ensures that methods and overall design parameters are developed centrally and implemented consistently across countries. At the same time, a research partner in each country is engaged to carry out the local research and participates in the global network. Research partners are selected through a competitive proposal process, and each represents a leading independent or university-based research organisation in its country (see list of local partners below). The country partners create local design plans and adapt instruments as required to ensure that the research is appropriate to the country context and serves local as well as global needs.

The target student age range for this research is 11 to 14, so the design in each country involves the level of schooling that serves most students at these ages. In different countries, this is either upper elementary or lower secondary school.

Each of these constructs and dimensions carries specific descriptions and meanings that are used throughout the ITL Research program and methods:

- *Innovative teaching practices* are the focal point of the investigation. As noted above, the construct of innovative teaching practices is defined as including three primary dimensions:

- *Student-centred pedagogies.* In the ITL model, student-centred pedagogies include practices of teaching and learning that are project-based, collaborative, foster knowledge building, require self-regulation and assessment, and are both personalised (allowing for student choice and relevance to the individual student) and individualised (allowing students to work at their own pace and according to their particular learning needs). Each of these elements has a strong base of prior research linking it to positive outcomes for students in terms of development of 21st century skills (for example, Bransford, Brown and Cocking, 1999; Darling-Hammond *et al.*, 2008).
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- Innovative teaching practices are shaped by a host of *school and educator-level factors*. The model focuses on three overarching constructs:
- *School culture and supports* that shape teaching practice. For example, research has shown that teacher *communities of practice* can provide a powerful force for change (Little, 2006) and that *school leadership* is a critical factor in providing the context for innovative practices to emerge and extend throughout a school (Shear *et al.*, 2010). *ICT access and support*, including such factors as location, availability, and functionality of ICT tools. Educators cite lack of technology access and support as a primary barrier to the integration of ICT in teaching and learning (Law, Pelgrum and Plomp, 2006). *Educator attitudes* shape educational reform in powerful ways. In ITL Research, this construct includes teacher beliefs about teaching and learning (for example, their beliefs about new *vs*. traditional pedagogies; Becker and Reil, 2000), teacher motivation and self-efficacy

(Gibson and Dembo,1984), and teacher attitudes towards ICT's value in teaching and learning.

- School and classroom factors operate in the context of national and regional education systems (including structure, policy, vision, and capacity) and program supports (such as professional development) which may be available through programs sponsored by government, NGOs, or the private sector.
- Finally, students' 21st century skills include broad skills that are seen as important goals of innovative teaching practices. The ITL Research model characterises these skills as knowledge building, problem-solving and innovation, skilled communication, collaboration, self-regulation and use of ICT for learning.

These key constructs are described in more detail in the ITL Research Design (available at *www.itlresearch.com*), including specific definitions that operationalise each of the constructs for the purposes of ITL Research.

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The target student age range for this research is 11 to 14, so the design in each country involves the level of schooling that serves most students at these ages. In different countries, this is either upper elementary or lower secondary school.

International workshops are conducted annually to train the local research teams on the constructs and research methods of ITL Research. Year 1 and Year 2 of the research include researcher collaboration and refinement of the methods based on prior year experience and findings in participating countries. Face-to-face researcher workshops are supplemented by regular telephone conferences and ongoing electronic communications between the global and country research partners in order to support and monitor ongoing consistency and research quality.

Table 6.1. **Global ITL research team**

Country	Role	Organisation
Global	Project sponsor	Microsoft Partners in Learning
USA	Project management and oversight	Langworthy Research
	Global research lead	Center for Technology in Learning, SRI International
Finland	Country research partner	Agora Center and Finnish Institute for Educational Research, University of Jyväskylä
	Government partner	National Board of Education
Indonesia	Country research partner	Centre for Strategic and International Studies
	Government partner	Ministry of National Education (MONE)
Russia	Country research partner	Institute of New Technologies, Moscow
	Government partner	The Academy for Teachers Training and Professional Retraining for Educators (APKiPPRO)
Senegal	Country research partner	Association of Teachers and Researchers of ICT in Education and Training
	Government partner	National Ministry of Education
Mexico	Country research partner	Proyecto Educativo SC
	Government partner	Secretaría de Educación Pública
UK	Country research partner	London Knowledge Lab
	National partner	Specialist Schools and Academies Trust

Methods, sample and outputs

For a systemic understanding of education ecosystems following the ITL Research logic model, it is necessary to collect data at multiple levels within the system, from the national or regional context to the school, educator, classroom and student levels. ITL Research uses a mixed methods approach, with an integrated design that provides consistent definitions and measures of essential constructs to ensure consistency across instruments. This multi-year study will collect data from each source annually to offer analysis of change over time.

ITL Research integrates these methods to provide data on the constructs in the logic model. Some constructs are measured through multiple methods.

For example, "Innovative Teaching Practices" are investigated through teacher surveys and interviews, classroom observations by trained researchers, and artifacts of classroom practice in the form of the learning activities that teachers ask students to carry out.

In each country, the samples of schools and educators are designed to reflect both what is considered innovative practice in that national context and "school as usual." Approximately 25 schools are selected in each country to participate in this research, to achieve a sample size of 650+ responses to the ITL teacher survey with a 70% to 80% response rate within each school. Schools in the sample are generally clustered in two or three geographic areas to make school site visits economically feasible.

ITL Research will also borrow from the model of action research. It sees research not only as a means of externally studying a situation, but as a direct

Table 6.2. **ITL research methods summary**

Method	Purpose	Levels of System Addressed
Surveys of teachers and school leaders	Provides quantitative data from a large sample of respondents to describe teacher and school leader experiences of national context and programs, school culture and supports, and self-reported beliefs and practices.	National/regional, school, educator, classroom
Interviews with school leaders and teachers	Provides richer and more contextualised data from a smaller sample of respondents on participants' experience of reform and the factors that shape it.	National/regional, school, educator, classroom
Analysis of Learning Activities and Student Work (LASW)	Uses artefacts of actual classroom practice to measure opportunities for 21st century learning according to a set of dimensions that are defined consistently across countries and classrooms.	Classroom, student
Classroom observations	Allows researchers to observe and describe classroom environments and learning activities in common ways across country and school contexts.	Classroom
Student focus groups[3]	Elicits data on students' experience of teaching and learning from a small sample of students.	Classroom, student
Interviews with national/regional education leaders	Provides system-level data on education goals, national programs and strategies, and challenges within the country.	National/regional
Achievement data	Where available, provides data on student academic achievement based on national exams.	Student

tool of engagement with teachers and schools. They become both partners in developing the methods and constituents of the research results who have an interest in "moving their numbers". ITL's initial plan was modified after the pilot year data collection to more directly incorporate the idea of the schools and educators as research partners. This direction came in part due to the difficulty of engaging schools and teachers in research projects in which they were not true stakeholders. It was also informed by one of the findings of the pilot year data analysis. Analysis of the ITL Research Teacher survey with teachers across the four countries showed that among seven different types of professional development, participation in "individual or collaborative research on a topic of interest to you professionally" had the strongest correlation with innovative teaching.[4] This suggests that educators who engage directly in research appear to also practice innovative teaching more frequently. Research, after all, is simply learning by another name. This led to the refinement of the ITL Research design after the pilot year to more directly engage schools and teachers in the research project by sharing the data results from their school with them and engaging them in professional development discussions related to the research methods and concepts behind them.

Finally, ITL Research will produce three categories of outputs based on the data collection efforts worldwide:

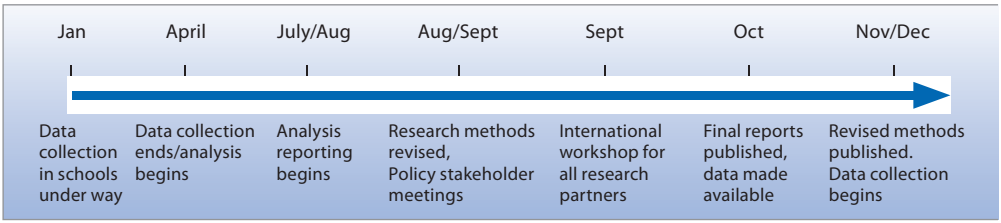
1. *Research findings*. Reports, journal publications and conference presentations at the global and country levels. These will begin to be published in the autumn of each year of the project based on the previous year's data collection and analysis.

2. *Quantitative data that can be used by other researchers*. Data from the ITL Teacher and School Leader surveys will be made available to interested educational researchers for further analysis (request at *www.itlresearch.com*). Over time, the project hopes to establish a community of international researchers and practitioners participating in the project, using the data and methods for further investigations and to inform professional development efforts.

3. *Methods*. As mentioned above, one of the major contributions of this project is the development of a set of tested and reliable methods for measuring innovative teaching and learning that can be used internationally. The instruments from each method and associated training and analysis materials will be made publicly available, though they will not be formally published until the conclusion of the project as each year refinements to each method are expected. Pilot year instruments are available online at *www.itlresearch.com*. Microsoft's Innovative Schools Program has already adopted the teacher and school leader surveys from ITL to establish a school-level evaluation system for the 40+ schools in the program internationally. This

school-level evaluation system based on ITL methods will be made an online service available at no cost to interested schools internationally in 2011 through Microsoft's Partners in Learning Network (*www.partnersinlearningnetwork.com*). The surveys and reports will be available in local languages.

Figure 6.4. **ITL research timeline – annual milestones for 2010-2012**



Policy implications

At conferences around the world, education researchers and government policy-makers have been discussing and examining what teachers and schools need to do to capitalise on ICT to help students attain 21st century learning goals. These leaders have been encouraging more innovative teaching and learning through their communications, their budget allocations for technology and their support for professional development focused on integrating technology in teaching and learning. In most cases, governments have not been measuring the degree to which teachers and schools implement changes in teaching practices. And very few governments have been positioned to measure the impact of changes in teaching practices on students' acquisition of new skills and capacities. Research supports the adage "you get what you measure". Lack of access to measures of innovative teaching and of students' 21st century skills hampers school improvement efforts and government initiatives to drive change.

One of the key findings of the OECD's Teaching and Learning International Survey (TALIS) was the significant positive impact that school evaluations and teacher appraisals have on both teachers' job satisfaction and their professional development. This study, which took place in 23 countries, highlighted the significance of the *specific content* of teacher appraisals and feedback:

The greater the emphasis on specific aspects of teacher appraisal and feedback, the greater the change in teachers' practices to improve their teaching. In some instances, more emphasis in school evaluations on certain aspects of

teaching is linked to an emphasis on these aspects in teacher appraisal and feedback which, in turn, leads to further changes in teachers' reported teaching practices. In these instances, the framework for the evaluation of education appears to be operating effectively (OECD, 2009).

However, roughly three quarters of teachers in the study reported they would receive no recognition for being more innovative in their teaching, suggesting that teacher appraisals are not currently aligned with claimed system goals for innovating teaching and learning. Qualitative findings from ITL Research's pilot year data collection also suggest that teachers and school leaders believe that their schools and practices are currently evaluated based on traditional areas of focus and content. This evaluation structure serves as a kind of perceptual barrier that protects the majority of teachers as they continue teaching practices in traditional ways. Even in an education system that allows a high degree of school autonomy, such as that of Finland, educators' practices are framed by the traditional learning goals articulated in policy:

Not all teachers are willing to develop. … Some teachers support strongly traditional teaching (ITL School Leader Interview, Finland). This is related to the teachers' high "self-accountability" on the normative goals embedded in the school curriculum in national and local levels. All teachers said in their interviews that they have a full autonomy to teach in the ways they see appropriate. The goals of national curriculum focus on subject learning. It is understandable that teachers attempt to carefully follow the stated goals. In such a situation, it is most convenient and safe to stick to the well-proven methods (Norrena and Kankaanranta, 2010).

Since most systems evaluate performance based on more traditional teaching and learning goals, education systems *de facto* support the inertia of existing practices that are designed to achieve traditional learning goals. Although education systems espouse education for the 21st century as a goal, many countries lack the kind of systemic alignment around that goal that will be needed for educational change.

Certainly there is a need to introduce clearly defined learning goals and assessments for students on the skills and capacity areas associated with life and work in the 21st century.[5] As described above, work on new student learning goals and assessments is ongoing in many different initiatives. However, systems also need to introduce innovative teaching practice goals, where the practices are directly aligned with the new learning goals and assessments. The achievement of these new teaching practice goals should be monitored and measured to ensure credibility in the eyes of teachers and school leaders. Thus, governments can support the transition to more innovative teaching practices by developing and promoting school and teacher evaluations that include measures of innovative teaching practices.

ITL Research can serve to address this need for new emphases in teacher evaluations by providing a consistent and tested set of methods for measuring teachers' practices with respect to dimensions of innovation (described above). By becoming involved in the ITL Research project, governments can have access to these methods and can further test and adapt them for professional development purposes or to measure their teachers' practices and how they are changing over time. If many governments choose to use common definitions and methods growing out of the ITL work, their data on teacher practice and student 21st century skills will have added meaning because they will be able to compare it to that of other countries. In this way, ITL-based methods and measures could become the basis of new international indicators of the use and effect of ICT for learning (Johannessen, 2009). Finally, the ITL research model and research results should be observed by governments and education system leaders for their potential to inform policy directions on ICT in education. This research can bring new insights to governments and schools' efforts to innovate in education. ITL can also provide a common language that supports international dialogue on what is working, what needs work, and how much progress is being made toward educational transformation.

To expand the scale of innovative educational transformation, governments, systems and schools need ways of measuring progress in innovative teaching and its impact on students' learning. If educational systems and schools begin to define and measure educational progress in a consistent way that includes innovative practice, it will signal a clear structural shift to school leaders and teachers that the system has a new set of goals more aligned with the needs and requirements of 21st century economies and societies. The goal of ITL Research is to contribute a set of consistent and tested methods to enable governments, education systems and schools worldwide to begin on this path.

Notes

1. For purposes of this study, "21st century learning outcomes" are defined as the following set of skills: knowledge building, problem-solving and innovation, skilled communication, collaboration, self-regulation, and use of technology for learning. These skills are defined more explicitly and in relation to the research methods in the ITL Research Design document and through the Learning Activities and Student Work Coding Guides, both available at *www.itlresearch.com*.
2. In the pilot year, this research question is being considered at a high level, and pilot data collected will be used to determine how much depth is appropriate for research on this question in subsequent years.
3. Student focus groups were not conducted in the pilot year but are planned for 2010 and 2011.
4. Because results cited in this report are based on pilot data, they should be considered preliminary and subject to confirmation in the main study.
5. ITL Research is currently in discussions with the ATC21S project about partnering the two projects in countries in which both projects are underway, such as Australia, Finland, the United Kingdom and the United States.

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Chapter 7

Design research on technology-based innovations

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The curriculum is, along with assessment, a key driver for education because curricula define goals, content and, in some cases, also the methods of teaching and learning. This chapter suggests that we regard curricula as a roadmap for education. In particular, the author looks at the benefits and limitations of curriculum design research and how its results have the potential to make an important contribution to curriculum policies and development. Rather than attempting to implement elaborate and complete interventions, a process whereby one comes to (successive) prototypes that increasingly meet the innovative aspirations and requirements is suggested. The process is often iterative, cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realisation has been achieved. The author concludes with some specific research characteristics that would strengthen the growth of knowledge through design research.

Introduction

Over the last decades and building upon experiences worldwide, a lot of research-based knowledge has grown about the potential added value of Information and Communication Technology (ICT) for education (see Voogt and Knezek, 2008). Although it is not easy to come to general conclusions about the uptake and impact of ICT on educational practices, the overall picture is rather sobering. There are scattered promising pockets of success, but the potential of ICT is still rarely realised. Integration of ICT use in schools remains slow and transfer of exemplary classroom practices appears to be limited. ICT seems a typical illustration of the statement by Hargreaves and Fink (2006) that change in education is easy to propose, hard to implement, and extraordinarily difficult to sustain. Thus, notwithstanding great ambitions and many investments, there is still a long way to go.

How may educational research help in addressing these challenges? Those contributions vary over different research approaches. Plomp (2009) distinguishes various questions, aims and functions of research, such as: to describe, to compare, to evaluate, to explain, to predict, to design and to develop. One may also discern various primary orientations of research: theory, practice or policy. Much policy-oriented research on ICT occurs through surveys, monitoring and assessment, focusing on (descriptive) measures about actual practices and outcomes of ICT. However, the central orientation in this paper will be on research that aims for ICT-related *improvement and innovation* of education, under the label of *design research*. Design reserach in education is a relatively new approach, with its roots in the early nineties, and since then documented in a number of special issues of prominent journals (for example: *Educational Researcher*, Vol. 32, No. 1, 2003; *Educational Psychologist*, Vol. 39, No. 4, 2004; *Journal of the Learning Sciences*, Vol. 13, No. 1, 2004; *Educational Technology*, Vol. 45, No. 1, 2005) and a number of books (for example: van den Akker, Gravemeijer, McKenney and Nieveen, 2006; and Kelly, Lesh and Baek, 2008).

Moreover, this paper takes a broad *curricular* perspective as that appears very helpful for systematically addressing the challenge of strengthening ICT in education because it transcends the often too narrow and isolated approach of studying the use and effects of ICT in teaching and learning.

Curricular Design Research intentionally combines two fields: "curriculum design" and "design research". In particular, it focuses on how design research can increase the quality of curriculum design and development (also in relation to ICT potential). Moreover, it illustrates how the relevance of educational research – a widely debated issue – can benefit from a connection to curriculum policies and practices.

Given this aim it helps to have a number of basic concepts and analytical perspectives available that can structure curricular deliberations and reduce the complexity of curriculum tasks. The initial focus in this chapter (building on van den Akker, 2003, and Thijs and van den Akker, 2009) is on summarising a set of concepts and perspectives that help to increase the transparency and balance of curriculum analysis, development and discourse. Then, the focus will shift towards (curricular) design research (building on van den Akker, 1999, and van den Akker *et al*., 2006).

Curriculum – what's in a name?

When there is a myriad of definitions of a concept in the literature (as with curriculum), it is often difficult to keep a clear focus on its essence. In those cases it often helps to search for the etymological origin of the concept. The Latin word "curriculum" (related to the verb *currere, i.e.* running) refers to a "course" or "track" to be followed. In the context of education, where learning is the central activity, the most obvious interpretation of the word "curriculum" is then to view it as a course, trajectory or "*plan for learnin*g" (*cf.* Taba, 1962). This very short definition (reflected in related terms in many languages) limits itself to the core of all other definitions, permitting all sorts of elaborations for specific educational levels, contexts, and representations. Obviously, contextual specification is always needed in curriculum conversations to clarify the perspective.

Given this simple definition, a differentiation between various levels of the curriculum has proven to be very useful when talking about curricular activities (policy making; design and development; evaluation and implementation). The next distinction appears to be helpful:

- International/comparative (or *supra* level).
- System/society/nation/state (or *macro*) level (*e.g.* national syllabi or core objectives).
- School/institution (or *meso*) level (*e.g.* school-specific curriculum).
- Classroom (or *micro*) level (*e.g.* textbooks, instructional materials).
- Individual/personal (or *nano*) level.

The supra level usually refers to international debates or agreements on aims and quality of education, sometimes fuelled by outcomes of internationally comparative studies. Curriculum development at the supra level is usually of a "generic" nature, while "site-specific" approaches are more applicable for the levels closer to school and classroom practice. Moreover, the process of curriculum development can be seen as narrow (developing a specific curricular product) or broad (a long term, ongoing process of

curriculum improvement, often including many related aspects of educational change, *e.g.* teacher education, school development, and examinations). In order to understand problems of curriculum decision-making and enactment, a broader description of curriculum development is often most appropriate: usually a long and cyclic process with many stakeholders and participants; in which motives and needs for changing the curriculum are formulated; ideas are specified in programs and materials; and efforts are made to realise the intended changes in practice.

Moreover, curricula can be represented in various forms. Clarification of those forms is especially useful when trying to understand the problematic efforts to change the curriculum. A common broad distinction is between the three levels of the "intended", "implemented" and "attained" curriculum. A more refined typology (van den Akker, 2003) is outlined in Table 7.1.

Table 7.1. **Typology of curriculum representations**

INTENDED	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/Written	Intentions as specified in curriculum documents and/or materials
IMPLEMENTED	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
ATTAINED	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Traditionally, the intended domain refers predominantly to the influence of curriculum policy makers and curriculum developers (in various roles), the implemented curriculum relates especially to the world of schools and teachers, and the attained curriculum has to do with the students.

Besides this differentiation in representations, curriculum problems can be approached from various analytical angles. For example, Goodlad (1994) distinguishes the following three different perspectives:

- *substantive,* focusing on the classical curriculum question about what knowledge is of most worth for inclusion in teaching and learning;
- *technical-professional,* referring to how to address tasks of curriculum development;
- *socio-political*, referring to curriculum decision-making processes, where values and interests of different individual and agencies are at stake.

Some might argue that this list is too limited as it refers especially to curriculum issues for "traditional" planning for learning in schools, and does not include the more "critical" perspectives that are amply present in curriculum theory literature (*e.g.* Pinar, Reynolds, Slattery and Taubman, 1995). However, from a primary interest in curriculum improvement, the three perspectives seem useful and appropriate.

Moreover, for the sake of technology-based innovations, it is important to notice that the various concepts, levels, perspectives and arguments in this part all have meaningful implications for a comprehensive approach.

The vulnerable curriculum spider web

One of the major challenges for curriculum improvement is creating balance and consistency between the various components of a curriculum (*i.e.* plan for learning). What are those components? The relatively simple curriculum definition by Walker (2003) includes three major planning elements: content, purpose and organisation of learning. However, curriculum design and implementation problems have taught us that it is wise to pay explicit attention to a more elaborated list of components. Elaborating on various typologies, we have come to adhere to a framework (see Table 7.2) of ten components that address ten specific questions about the planning of student learning.

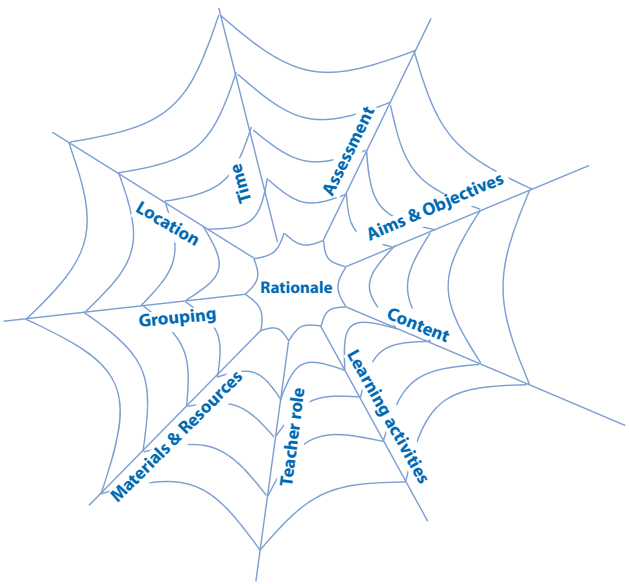
Table 7.2. **Curriculum components**

Rationale or Vision	Why are they learning?
Aims and Objectves	Toward which goals are they learning?
Content	What are they learning?
Learning Activities	How are they learning?
Teacher Role	How is the teacher facilitating learning?
Materials and Resources	With what are they learning?
Grouping	With whom are they learning?
Location	Where are they learning?
Time	When are they learning?
Assessment	How to measure how far learning has progressed?

The "rationale" (referring to overall principles or central mission of the plan) serves as major orientation point, and the nine other components are ideally linked to that rationale and preferably also consistent with each other. For each of the components many sub-questions are possible. Not only on substantive issues (see the next part), but, for example, also on "organisational" aspects as:

- Grouping:
  - How are students allocated to various learning trajectories?
  - Are students learning individually, in small groups or whole-class?
- Location:
  - Are students learning in class, in the library, at home or elsewhere?
  - What are the social/physical characteristics of the learning environment?
- Time:
  - How much time is available for various subject matter domains?
  - How much time can be spent on specific learning tasks?

Figure 7.1. **Curricular spider web**



Our preferential visualisation of the ten components is to arrange them as a spider web (Figure 7.1), not only illustrating its many interconnections but also underlining its vulnerability. Thus, although the emphasis of curriculum design on specific components may vary over time, eventually some kind of alignment has to occur to maintain coherence. A striking example is the trend toward integration of ICT in the curriculum with (usually) initial attention to changes in materials and resources. Many implementation studies have exemplified the need for a more comprehensive approach and systematic attention to the other components before one can expect robust changes.

The spider web also illustrates a familiar expression: every chain is as strong as its weakest link. That seems another very appropriate metaphor for a curriculum, pointing to the complexity of efforts to improve the curriculum in a balanced, consistent and sustainable manner.

Perspectives on substantive choices

A classic approach to the eternal question of what to include in the curriculum (or even more difficult as well as urgent: what to exclude from it) is to search for a balance between three major sources or orientations for selection and priority setting:

- Knowledge: what is the academic and cultural heritage that seems essential for learning and future development?
- Society: which problems and issues seem relevant for inclusion from the perspective of societal trends and needs?
- Learner: which elements seem of vital importance for learning from the personal and educational needs and interests of the learners themselves?

Answers to these questions usually constitute the rationale of a curriculum. Inevitably, choices have to be made, usually involving compromises between the various orientations (and their respective proponents and pressure groups). Oftentimes, efforts fail to arrive at generally acceptable, clear and practical solutions. The result of adding up all kinds of wishes is that curricula tend to get overloaded and fragmented. Implementation of such incoherent curricula eventually tends to lead to student frustrations, failure and dropout.

How to create a better curriculum balance? Easy answers are not available, but a few alternatives seem to have some promise. First, in view of the multitude of (academic) knowledge claims, it sometimes helps to reduce the big number of separate subject domains to a more limited number of broader learning areas, combined with sharper priorities in aims for learning (focusing on basic concepts and skills).

Second, referring to the avalanche of societal claims, more interaction between learning inside and outside the school may reduce the burden. However, the most effective response is probably to be more selective in reacting to all sorts of societal problems. As Cuban (1992) phrased it clearly: schools should not feel obliged to scratch the back of society every time society has an itch.

And third, about the learners' perspective: worldwide, many interesting efforts are ongoing to make learning more challenging and intrinsically motivating by moving from traditional, teacher and textbook-dominated instruction towards more meaningful and activity-based learning approaches.

Obviously, ICT creates new challenges but also offers new opportunities for addressing the substantive dilemmas described.

Development strategies

To sketch curriculum development as a problematic domain is actually an understatement. From a socio-political stance, it often seems more appropriate to describe it as a war zone, full of conflicts and battlefields between stakeholders with different values and interests. Problems manifest themselves in the (sometimes spectacular and persistent) gaps between the intended curriculum (as expressed in policy rhetoric), the implemented curriculum (real life in school and classroom practices), and the attained curriculum (as manifested in learner experiences and outcomes). A typical consequence of those tensions is that various frustrated groups of participants blame each other for the failure of reform or improvement activities. Although such blaming games often seem rather unproductive, there are some serious critical remarks to be made on many curriculum development approaches worldwide. First of all, many curriculum reform efforts can be characterised by overly big innovation ambitions (especially of politicians) within unrealistically short timelines and with very limited investment in people, especially teachers. Unfortunately, many ICT-related reforms have suffered from this problem. Second, oftentimes there is a lack of coherence between the intended curriculum changes with other system components (especially teacher education and assessment/examination programs). And last but not least, timely and authentic involvement of all relevant stakeholders is often neglected.

From a strategic point of view, the literature has offered us many (technical-professional) models and strategies for curriculum development. Three prominent approaches are Tyler's rational-linear approach, Walker's deliberative approach, and Eisner's artistic approach. As it does not fit within the purpose of this chapter to explain those models in particular, the reader is referred to educative texts from Marsh and Willis (2003) or to the overview of prominent approaches in Thijs and van den Akker (2009).

Obviously, the context and nature of the curriculum development task at hand will determine to a large extent what kind of strategy is indicated. It is noteworthy that we are beginning to see more blended approaches that integrate various trends and characteristics of recent design and development approaches in the field of education and training (for an overview and a series of examples, see van den Akker, Branch, Gustafson, Nieveen and Plomp, 1999, or van den Akker and Kuiper, 2009). Some key characteristics:

- Pragmatism: recognition that there is not a single perspective, overarching rationale or higher authority that can resolve all dilemmas for curriculum choices to be made. The practical context and its users are in the forefront of curriculum design and enactment.
- Prototyping: evolutionary prototyping of curricular products and their subsequent representations in practice is viewed as more productive than quasi-rational and linear development approaches. Gradual, iterative approximation of curricular dreams into realities may prevent paralysis and frustrations. Formative evaluation of tentative, subsequent curriculum versions is essential to such curriculum improvement approaches.
- Communication: a communicative-relational style is desirable in order to arrive at the inevitable compromises between stakeholders with various roles and interests and to create external consistency between all parties involved.
- Professional development: In order to improve chances on successful implementation, there is a trend towards more integration of curriculum change and professional learning and development of all individuals and organisations involved.

Design or development(al) research is a research approach that incorporates some of these characteristics, and it becomes even more promising by adding the element of knowledge growth to it. Such research can strengthen the knowledge base in the form of design principles that offer heuristic advice to curriculum development teams, when (more than in common development practices) deliberate attention is paid to theoretical embedding of design issues and empirical evidence is offered about the practicality and effectiveness of the curricular interventions in real user settings.

However, there are several persistent dilemmas for curriculum development that cannot easily be resolved, let alone through generic strategies. For example: how to combine aspirations for large-scale curriculum change and system accountability with the need for local variations and ownership? The tension between these conflicting wishes can be somewhat reduced when one avoids the all too common “one size fits all” approach. More adaptive and flexible strategies will avoid detailed elaboration and over-specification of central curriculum frameworks. In-stead, they offer substantial options

and flexibility to schools, teachers, and learners. Although struggles about priorities in aims and content will remain inevitable, the principle of "less is more" should be pursued. However, what is incorporated in a core curriculum should be clearly reflected in examination and assessment approaches.

The "enactment" perspective (teachers and learners together create their own curriculum realities) is increasingly replacing the "fidelity" perspective on implementation (teachers faithfully follow curricular prescriptions from external sources). That trend puts even more emphasis on teachers as key people in curriculum change. Both individual as well as team learning is essential (Fullan, 2007). Teachers need to get out of their customary isolation. Collaborative design and piloting of curricular alternatives can be very productive, especially when experiences are exchanged and reflected upon in a structured curriculum discourse. Interaction with external facilitators can contribute to careful explorations of the "zone of proximal development" of teachers and their schools. Cross-fertilisation between curriculum, teacher, and school development is a *conditio sine qua non* for effective and sustainable curriculum improvement. The increasingly popular mission statements of schools to become attractive and inspiring environments for students and teachers can only be realised when such integrated scenarios are practised.

The potential of curriculum design research

Various motives for initiating and conducting curriculum design research can be mentioned. A basic motive stems from the experience that many research approaches (*e.g.* experiments, surveys, correlational analyses), with their focus on descriptive knowledge, hardly provide prescriptions with useful solutions for a variety of design and development problems in education. Probably the greatest challenge for professional designers is how to cope with the manifold uncertainties in their complex tasks in very dynamic contexts. If they do seek support from research to reduce those uncertainties, several frustrations often arise: answers are too narrow to be meaningful, too superficial to be instrumental, too artificial to be relevant, and, on top of that, they usually come too late to be of any use. Curriculum designers do appreciate more adequate information to create a solid ground for their choices and more timely feedback to improve their products. Moreover, the professional community of developers as a whole would be helped by a growing body of knowledge of theoretically underpinned and empirically tested design principles and methods.

Another reason for curricular design research stems from the highly ambitious and complex nature of many curriculum reform policies in education worldwide. These reform endeavours usually affect many system components, are often multi-layered, including both large-scale policies and small-scale realisation, and are very comprehensive in terms of factors

included and people involved. Those radical "revolutions", if promising at all, cannot be realised on the drawing table. The scope of diverse needs is often very wide, the problems to be addressed are usually ill-specified, the effectiveness of proposed interventions is mostly unknown beforehand, and the eventual success is highly dependent on implementation processes in a broad variety of contexts. Therefore, such curriculum reform efforts would profit from more evolutionary (interactive, cyclic, spiral) approaches, with integrated research activities to feed the process (both forward and backward). Such an approach would provide more opportunities for "successive approximation" of the ideals and for more strategic learning in general. In conclusion: curriculum design research seems a wise and productive approach for curriculum development. And innovative efforts to integrate ICT in education is an excellent example of such challenges.

Features of curriculum design research

Curriculum design research is often initiated for complex, innovative interventions for which only very few validated principles are available to structure and support the design and development activities. Since in those situations the image and impact of the intervention to be developed is often still unclear, the research focuses on realising limited but promising examples of those interventions. The aim is not to elaborate and implement complete interventions but to come to (successive) prototypes that increasingly meet the innovative aspirations and requirements. The process is often iterative, cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realisation has been achieved.

To what extent do these design research activities differ from what is typical for design and development approaches in professional practices? What are the implications of the accountability of researchers to the "scientific forum"? At the risk of exaggerating the differences, let us outline some of them, based on what is known about routinised standard-patterns in curriculum development practices. Of course, a lot of activities are more or less common for both approaches, so the focus will be on those additional elements that are more prominent in design research than in common design and development practices.

Preliminary investigation

A more intensive and systematic preliminary investigation of curriculum tasks, problems and context is made, including searching for more accurate and explicit connections of that analysis with state-of-the-art knowledge from literature. Some typical activities include: literature review; consultation of experts; analysis of available promising examples for related purposes; case

studies of current practices to specify and better understand needs and problems in intended user contexts.

Theoretical embedding

More systematic efforts are made to apply state-of-the-art knowledge in articulating the theoretical rationale for curriculum design choices. Moreover, explicit feedback to assertions in the design rationale about essential characteristics of the intervention (substantive design principles) is made after empirical testing of its quality. This theoretical articulation can increase the "transparency" and "plausibility" of the rationale. Because of their specific focus, these theoretical notions are usually referred to as "mini" or "local" theories although sometimes connections can also be made to "middle-range" theories with a somewhat broader scope.

Empirical testing

Clear empirical evidence is delivered about the practicality and effectiveness of the curriculum for the intended target group in real user settings. In view of the wide variation of possible interventions and contexts, a broad range of (direct/indirect; intermediate/ultimate) indicators for "success" should be considered.

Documentation, analysis and reflection on process and outcomes

Much attention is paid to systematic documentation, analysis and reflection on the entire design, development, evaluation and implementation process and on its outcomes in order to contribute to the expansion and specification of the methodology of curriculum design and development.

Typical questions for design research are:

- What are essential features of successful interventions? (For complicated challenges or "wicked" problems, *cf.* Kelly, 2009.)
- How do those interventions operate in real life?
- How can they be developed and implemented?

In view of its aim, design research is never a "quick fix" operation, but it usually takes a long trajectory, where the research is intertwined with continuous development activities – from problem formulation up to and including implementation.

More than most other research approaches, design research aims at making both practical and scientific contributions. In the search for innovative

"solutions" for curriculum problems, interaction with practitioners (in various professional roles: teachers, policy makers, developers, and the like) is essential. The ultimate aim is not to test whether theory, when applied to practice, is a good predictor of events. The interrelation between theory and practice is more complex and dynamic: is it possible to create a practical and effective curriculum for an existing problem or intended change in the real world? The innovative challenge is usually quite substantial, otherwise the research would not be initiated at all. Interaction with practitioners is needed to gradually clarify both the problem at stake and the characteristics of its potential solution. An iterative process of "successive approximation" or "evolutionary prototyping" of the "ideal" intervention is desirable. Direct application of theory is not sufficient to solve those complicated problems. One might state that a more "constructivist" development approach is preferable: researchers and practitioners co-operatively construct workable interventions and articulate principles that underpin the effects of those interventions.

Another reason for co-operation is that without involvement of practitioners it is impossible to gain clear insight in potential curriculum implementation problems and to generate measures to reduce those problems. New interventions, however imaginative their design, require continuous anticipation at implementation issues. Not only for "social" reasons (to build commitment and ownership of users) but also for "technical" benefits: to improve their fitness for survival in real life contexts. Therefore, rigorous testing of practicality is a *conditio sine qua non* in design research.

Emphasis on formative evaluation

As has become clear in the previous parts, formative evaluation holds a prominent place in curricular design research. The main reason for this central role is that formative evaluation provides the information that feeds the optimisation of the intervention and the cyclic learning process of curriculum developers during the subsequent loops of a design and development trajectory. It is most useful when fully integrated in a cycle of analysis, design, evaluation, revision, etc., and when contributing to improvement of the curriculum.

Thus, the basic contribution of formative evaluation is to quality improvement of the curriculum under development. Quality, however, is an abstract concept that requires specification. During development processes, the emphasis in criteria for quality usually shifts from relevance to consistency, to practicality, to effectiveness.

Relevance refers to the extent that the intended curriculum is perceived to be a relevant improvement to practice, as seen from the varied perspectives of policy makers, practitioners and researchers. *Consistency* refers to the extent that the design of the curriculum is based on state-of-the-art knowledge and

that the various components of the intervention are consistently linked to each other (*cf.* the curricular spider web). *Practicality* refers to the extent that users (and other experts) consider the intervention as clear, usable and cost-effective in "normal" conditions. *Effectiveness* refers to the extent that the experiences and outcomes with the intervention are congruent with the intended aims. Also, issues of scalability and sustainability may be included in a broad interpretation of effectiveness.

The methods and techniques for evaluation will usually be attuned to that shift in criteria (*cf.* the various stages of alpha, beta and gamma testing in the IT sector). For example, adequate evaluation of validity can start with comments of critical friends on initial drafts and then move over to more systematic expert appraisal. Practicality is often tested *via* micro-evaluations and try-outs in real classroom practices. Evaluation of effectiveness usually requires (more large scale) field tests. In later stages of formative evaluation, methods of data collection will usually be less intensive but with an increasing number of respondents (*e.g.* achievement test for many students at the end compared to in-depth interview with a few experts in the beginning). See Nieveen (2009) for more elaborate explanations and suggestions for these shifts in formative evaluation.

Formative evaluation within design research should not only concentrate on locating shortcomings of the intervention in its current (draft) version but especially generate suggestions on how to improve those weak points. Richness of information, notably salience and meaningfulness of suggestions on how to make an intervention stronger, is therefore more productive than standardisation of methods to collect and analyse data. Also, efficiency of procedures is crucial. The lower the costs in time and energy for data collection, processing, analysis and communication will be, the bigger the chances of actual use and impact on the development process. For example, samples of respondents and situations for data collection will usually be relatively small and purposive compared to sampling procedures for other research purposes. The added value of getting "productive" information from more sources tends to decrease because the opportunities for "rich" data collection methods (such as interviews and observations) are limited with big numbers. To avoid an overdose of uncertainty in data interpretation, often triangulation (of methods, instruments, sources and sites) is applied. These arguments especially hold true for early stages of formative evaluation when the intervention is still poorly crystallised.

Generalisation of curricular design research findings

In practical terms, the most relevant outcome of curricular design research is its contribution towards optimisation of the curricular product and its actual use, leading to better instructional processes and learning results. However, a

major contribution to knowledge to be gained from design research is in the form of "design principles" (both substantive and methodological) to support developers in their task. Those principles are usually incorporated within (a growing set of) heuristic statements, following a format such as:

- *If you want to design intervention X [for purpose/function Y in context Z]*
- *then you are best advised to give that intervention the characteristics C_1, C_2,..., C_m [substantive emphasis]*
- *and to do that via procedures P_1, P_2, ..., P_n [procedural emphasis]*
- *because of theoretical arguments T_1, T_2, ..., T_p*
- *and empirical arguments E_1, E_2, ..., E_q.*

Obviously those principles cannot guarantee success, but they are intended to select and apply the most appropriate (substantive and procedural) knowledge for specific design and development tasks.

It is not uncommon in design research that such knowledge, especially the substantive knowledge about essential curriculum characteristics, can partly be extracted from a resulting prototype itself. That is one of the reasons that makes it so profitable to search for and carefully analyse already available curricula to generate ideas for new design tasks. However, the value of that knowledge will strongly increase when justified by theoretical arguments, well-articulated in providing directions, and convincingly backed-up with empirical evidence about the impact of those principles. Moreover, those heuristic principles will be additionally powerful if they have been validated in successful design of more interventions in more contexts. Chances for such knowledge growth will increase when design research is conducted in the framework of research programs, because projects can then build upon one another.

Since data collection in design research is often limited to small (and purposive) samples, efforts to generalise findings cannot be based on statistical techniques, focusing on generalisations from sample to population. Instead one has to invest in "analytical" forms of generalisation (*cf.* Yin, 2003): readers/users need to be supported to make their own attempts to explore the potential transfer of the research findings to theoretical propositions in relation to their own context. Reports on design research can facilitate that task of analogy reasoning by a clear theoretical articulation of the design principles applied and by reflection on the results afterwards. Moreover, it is helpful to offer a careful description of both the evaluation procedures as well as the implementation context. Especially a "thick" description of the process-in context may increase the "ecological" validity of the findings, so that others can estimate in what respects and to what extent transfer from the reported situation to their own is possible. Another option that may stimulate exploration

of possibilities for (virtual) generalisation and transfer to various settings is to organise interactive (network) meetings with experts and practitioners from related contexts to discuss the plausibility of the research findings and recommendations for related tasks and contexts.

Last but not least, curricular design research may offer drafts of various relevant curriculum versions (with proven consistency and practicality) that can be compared in more quantitative, large-scale (quasi-)experimental studies.

Conclusion

In view of the (rapidly growing but still relatively) modest familiarity of educational design research to the wider audience, it is wise to invest a lot in the transparency, plausibility, "trustworthiness", and "reconstructiveness" of its arguments and findings. Also at stake is the "credibility" (expertise in depth and breadth; track record) of research team and partners.

For closure, we briefly mention some research characteristics that strengthen the growth of knowledge through design research:

- "Standing on shoulders": less isolated studies, but deliberate efforts to build on previous research and development work through a programmatic approach.
- Variation and adaptability in intervention and methodology.
- Deliberate triangulation in sites and sources of data gathering.
- Increasing insight in essence of successful interventions *versus* variations in other features.
- Preventing premature closure to seemingly effective but limited interventions.
- Knowledge sharing and distribution through systemic partnerships and networks.
- Involvement and joint professional development of many partners: teachers, school leaders, teacher educators, researchers, curriculum and textbook developers, assessment specialists, etc.

The more these characteristics receive attention, design research is also a very promising avenue for technology-based innovation.

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Part IV

Conclusions

Chapter 8

Lessons learnt and policy implications

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This final chapter summarises the lessons learnt from the OECD expert meeting held in Florianopolis (Brazil) in November 2009 as well as the policy implications. On the whole, it addresses the issue of how a systemic approach can improve our understanding of how technology-based school innovations work and how local innovations can be scaled up successfully. In times of economic crisis, a systemic approach to technology-based innovation in education is even more urgently needed. Most countries are now facing difficult times, and OECD member states are no exception to this. The immediate programmes that many governments have launched – sometimes in a co-ordinated way, with the aim of facing the financial crisis – have also been coupled in many cases with in-depth reflection about the way in which our economies work and with strategies to promote longer-term development and vision. In the context of this reflection, it becomes apparent that in the medium and long-term, innovation will increasingly be a key factor not only to economic growth but also to social welfare. The efforts to sustain technology-based innovations in education should be no exception to this. In the light of the financial crisis, each educational system should improve its ability to scale up technology-based innovation for improved learning outcome and learning strategies.

Lessons learnt

The expert meeting in Florianopolis discussed a range of topics related to innovation, technology and learning over the course of the two-day meeting. The conclusions that are presented here are some of the preliminary conclusions that were drawn at the end of the meeting. A note of caution is pertinent here, because these conclusions do not constitute the full ptechnologyure of the meeting, but they give an overview over some critical issues that were discussed.

1. **There is an imbalance between investments in infrastructure, content, support and teacher training and the required efforts to build a sustainable knowledge base regarding technology-based school innovations**. What does this mean? The answer is quite simple. Many countries have been investing heavily in the core strategic components for technology in education in order to foster its use in teaching and learning, but evidence from, for example, the OECD study on systemic innovation in digital learning resources in the Nordic countries suggests that a sufficient knowledge base is not available, and the existing knowledge has barely been tapped into.
2. **There is a tension between technology and pedagogy**. There are more cases of technology-driven innovations than of pedagogy-driven innovations. This conclusion suggests that the availability and, in some cases, even the fascination for technology is the main driver behind innovations in this area. The link between technology and pedagogy is too weak or in the worst case non-existent, which seriously inhibits the potential of the educational system to be at the forefront of the utilisation of technologies for learning.
3. **There is an axis between radical and incremental innovation**. This finding is aligned with the discussion about whether innovations only can be radical, or whether innovations can be undertaken in small steps. Some of the innovations mentioned at the expert meeting were well inside the box of an educational system, while other innovations where "out-of-the box" innovations taking a truly different view of education from the outset.
4. **There is a need to balance the expectations of the power of technology with the reality of what is feasible**. Since the first half of the 20th century, technological innovations have been said to have revolutionary possibilities for education. Over the decades, we have seen various expressions of this. There is a need to find a good balancing point between what technologies have to offer and the financial, organisational and pedagogical realities of education.

5. **The complexity of the issues at stake requires a multi-layered, multi-disciplinary and multi-methodological approach**. Technology-based innovations address all aspects and all stakeholder groups of education. The phases of innovation and the need for good M&E systems underpin this conclusion.

6. **The potential of "new" research disciplines such as brain research and research on learning environments must be explored**. This conclusion highlights the need to engage research disciplines that in the past have not been involved in issues related to technology in learning. Such an approach could be useful in order to embed technology in core issues related to teaching and learning.

7. **Current work on assessment seems to be limited to digital literacy**. Further research should be grounded in classroom practice. Some of the examples mentioned at the expert meeting show that the foremost use of technology related to the assessment of digital literacy, *cf.* the Australian case. There is a need to expand the use of technology for literacy to other areas, and a focus on both formative and summative assessment should be upheld.

8. **There is a need for a social dialogue on educational innovations involving all stakeholders**. This conclusion supports the view taken in the OECD Innovation Strategy that innovation processes today are considered to be social, multi-stakeholder oriented. Without sufficient stakeholder involvement, the risk of innovation failure is likely to increase.

9. **Research must be translated into meaningful guidelines for improving practice**. Innovations will never become true innovations if they are not put into practice. This conclusion points both to the importance of a solid knowledge base, in which empirical evidence from pedagogical practice is also included, as well as a fruitful dialogue with practitioners in order to facilitate good implementation strategies for technology in teaching and learning.

10. **To what extent is research evidence phased into the education and practice of teachers?** This open question raises two important issues. Firstly, educational systems need to ensure that research evidence related to technology and learning is made available in a "teacher-friendly" format. Secondly, the professional culture and professional development of teachers should address an orientation towards research evidence as a part of the professional ethos among teachers. A third issue is related to the question about whether teacher training institutions manage to be at the forefront of the development of the discourse on technology in teaching and learning. This issue is addressed by the ongoing OECD project on technology use in initial teacher training.

Policy principles

These conclusions drawn from the discussions at the meeting can be combined with the main results of previous CERI work on systemic innovation and on technology in education. The result suggests a number of important principles for policy actions.

Systemic innovation is a useful analytical framework for the assessment of innovation policies.

The main benefit of the systemic innovation approach is that it can help governments and other stakeholders to have a comprehensive evaluation of how the system works and how they can enhance their own innovation capacity. It is thus relevant from a policy perspective because it clarifies what information gaps exist, and particularly where, in the lifecycle of the innovation, a good evidence base might be more useful. In the end, the systemic approach to innovation contributes to the assessment of how the innovation system works and to the identification of policies that are capable of boosting the innovative potential of technology in education.

Although efforts to develop a systemic approach to innovation in this field are still rare, they have the potential to develop better processes and to contribute to an incremental improvement of the education system.

A coherent and targeted system should be in place to promote and support successful innovations and to induce system-wide change. Such systems are still infrequent at the country level.

The need to respond in a timely manner to the socio-economic and technological challenges that all education systems are facing in an increasingly globalised and rapidly changing world seem to be driving most technology-based innovations. Political leadership and capacity to steer and manage the innovation, the availability of resources, and/or the existence of regulatory mechanisms supporting the process seem to play a crucial enabling role in most systemic innovations. Equally, the availability of evidence and a good level of consensus among stakeholders also seem to play a crucial role during the design and implementation of the innovations.

Nevertheless, innovation enablers and barriers are not universal but rather context specific. While it is true that their presence or absence will facilitate or hinder the innovation processes in any education system, their importance seems to vary depending on the cases and the context. This is particularly true of the role of consensus among stakeholders, of evidence and of political leadership. In particular, evidence can facilitate the adoption of innovation and inform the process – although the existing evidence suggests that innovations

primarily draw upon tacit knowledge and beliefs or a sense of urgency to change the *status quo*.

In the domain of technology-based innovations, education systems need a formalised, coherent, well-sustained and up-to-date knowledge base to increase their innovation capacity, to address knowledge gaps and to fully benefit from systemic innovations.

Technology-based school innovations are rarely the result of an embodied set of knowledge or empirical evidence accumulated over the years, knowledge or evidence from which stakeholders nourish their decisions and to which they contribute with their feedback. Moreover, countries do not seem to pay enough attention to monitoring and evaluating how technology-based innovations, particularly those whose realisation requires a large amount of policy commitment and financial investment, evolve in the context of the system. In addition, little has been done to assess when a particular innovation can be said to be a success or a failure and what lessons can be learned as a result.

Although there has not been empirical validation of the assumption that a better knowledge base results in more successful innovations in our case studies, the existing lack of a link between research and innovation efforts is remarkable. This is reflected mostly at the government level, with a generalised lack of attention given to the issue of merging both activities to result in a coherent knowledge base. It is also clear that innovation, on the one hand, and research, on the other, seem to appeal to different profiles of education professionals.

Finally, it is particularly perplexing to see the lack of research evidence and gaps in the feedback loop of the evaluation process in conjunction with the push for greater accountability and increased assessment of the system, teachers and students. This is a clear incoherence in the system that needs to be addressed.

Education systems may be losing innovation opportunities due to a lack of evaluations and knowledge feedback into the system.

Despite its potential, the evaluation of innovations seems to be a missing feature of education systems. This applies equally to local and discrete innovations as well as to top-down innovations, including those aiming for system-wide impact. There may be many explanations for this, ranging from the lack of sustained research efforts in the particular domain of technology in education, the disconnection between practitioners, researchers and policy makers, the lack of dedicated mechanisms to gather relevant information or even the prevalent culture of the sector.

A particular situation where the relevance of evaluation becomes even clearer is piloting. Pilots fulfil a very important role in those systemic innovations that aim at having a deep impact on the system. While they are costly in terms of time and resources, they play an important role in the prevention of implementation gaps and innovation fatigue. Piloting may be useful for technical and organisational purposes, but unless a monitoring and evaluation procedure is carefully implemented, the benefits of piloting may be lost.

The analysis of technology-based innovation in education

The work done during the expert meeting led to the identification of four axes for the analysis of technology-based innovations in education. These are:

- The policy axis
- The pedagogical axis
- The technology axis
- The knowledge axis

The policy axis is necessary in order to highlight a systemic approach as a prerequisite for long-term horizon in technology-based innovation in education. The pedagogical and technological axes are the main domains when we talk about technology in learning. The knowledge axis is selected because of the key importance attached to having an available knowledge base for innovation.

Policy axis

The policy axis emphasises the need to approach innovation in education in a systemic fashion – *i.e.* looking at innovations that the educational system in a country, a state or a region can benefit from – and this axis links innovation to policy making and policy choices that need to be made in order to facilitate innovation, its impact and its knowledge base.

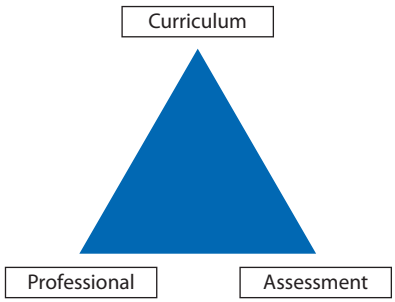
One of the most important challenges for innovation policies for technology in education is to ensure sufficient **policy coherence**. The various policy elements cannot be regarded in isolation; they are elements that are interrelated, and they are often necessary for other policy elements to be effective. Policy coherence lies at the heart of the systemic approach to innovation through its focus on policy elements and their internal relations.

In order to give a deeper understanding of policy coherence, we can make the simple distinction between **horizontal** and **vertical** coherence in an

educational system. The horizontal coherence refers to the links between the key elements in a policy or strategy whereas the vertical coherence refers to the links or channels through various levels of the educational system. Both types of coherence will be elaborated in the following text.

With regard to horizontal coherence, this approach is necessary in order to understand how different policy elements interplay. The following figure shows a simplified model of coherence between key policy elements. This simplified model is not intended to be prescriptive with regard to the most important policy elements. In most cases, curriculum, professional development for teachers and school leaders and assessment are key elements in any context.

Figure 8.1. **Simplified model of coherence between key policy elements**



Coherence between key elements in the promotion of innovations in education

To give an example of the interrelations we are talking about here, we can look at the relation between curriculum and assessment. In many countries, curriculum is the key driver for education, and the curriculum can be regarded as the contract between education and society at large. In some cases, the curriculum is changed in order for education to keep up with changes in society and changes in the demands on the future workforce. However, if this change occurs without similar changes in the system of assessment, the lack of assessment change may act as an inhibitor for educational change because assessment is, in many countries, one of the most important drivers for educational change.

In a similar way, changes in the curriculum should be followed by professional development among teachers because teachers need to be enabled to implement the changes in the curriculum (and in the assessment system).

The simplified model can be said to represent a core set of horizontal policy coherence. There are, of course, other important areas to consider, such as infrastructure, policies on open standards and interoperability, digital learning resources, etc.

The horizontal coherence is important in order to secure a robust implementation of innovations and educational change. This cuts both ways, of course. Bottom-up innovations require links between different levels in the educational system in order to be communicated to national authorities, which can be important, *e.g.* when it comes to the scaling up of innovation.

A common experience across countries is that the road from the Ministry of Education to each classroom seems very long. Sufficient vertical policy coherence can be a means to reduce this distance.

In considering the issue of policy coherence, countries and regions should also take into consideration how policies for technology-based innovation are related to the overall policies and goals of regional or national education. Across countries, there are variations as to how countries design their strategies. Some countries have dedicated policies for technology in education. Some of these policies cover a wide spectre of issues, *i.e.* they encompass all key policy elements for technology in education. Other countries have more focused strategies. This seems to be the case in a number of countries that have developed strategies for what is commonly known as "1 to 1 computing", *i.e.* ensuring that most learners are equipped with laptops, notebooks etc. These strategies normally have elements of professional developments embedded, but the core of these strategies is to ensure access and equity among learners with regard to technology in education. Other countries do not have separate technology strategies because technology is embedded in overall national strategies and policies. For example, this is the case in Norway and Sweden.

Making policy coherence work is an important factor when it comes to linking, *e.g.* research and classroom practice. As Hung *et al.* have pointed out in their chapter; we need to pay careful attention to the translation process from the initiation of innovation to the implementation of innovation. Some countries have established national centres or agencies for technology in education such as Becta in the United Kingdom or the Centre for Technology in Education in Norway. Such agencies are important mediators between policy, practice and research, and they play an important role in the acquisition and dissemination of knowledge. Using mediating agents can also be an important mechanism for effective policy deployment. Educational systems are normally multi-layered, complex systems. Many educational systems have a medium or high degree of decentralisation, with varying degrees of autonomy and accountability located at regional or local levels. The number of stakeholders is relatively high, and they represent different interests. This

puts some limitations on how the central government can act with regard to policy implementation. In some countries, there is a federal government structure, which requires a well developed interplay between levels of government in order to reduce the risk of policy implementation failure.

Pedagogical axis

The pedagogical axis is largely about how technology can contribute to improved learning outcomes and learning strategies among learners. This is the key challenge when it comes to technology and learning, and we will focus on some critical areas in this chapter.

The curriculum is, along with assessment, a key driver for education, because curricula define goals, content and, in some cases, also the methods of teaching and learning. To paraphrase Professor van den Akker's contribution, we can regard curricula as the roadmap for education.

The first issue is how we can approach the curriculum with regard to innovation. As the curriculum enables practitioners to navigate through the key areas of each subject or discipline, the curriculum can offer what we may label as "zones of innovation". Let us take a look at a couple of examples. Firstly, in a subject like English (as a first language), it is important to look at and work with different text genres, in some cases we refer to what is called multimodal text (Multimodal texts are those that combine, for example, print text, visual images and spoken word as in film or computer presentation media). A strategy sometimes preferred by teachers is to let learners work collaboratively on multimodal texts, and this is an area where some teachers prove to be innovators in how they use, for example, social media such as blogs and wikis to facilitate collaborative writing.

Another example of how technology is used to improve teaching and learning is to use simulations and visualisation in science. This highlights how technology can improve the teaching and learning process by enabling pedagogical approaches that are impossible or more difficult to facilitate without the use of technology. Key here is that teachers are able to identify those parts of the curriculum – the curricular zones of innovation – where technology can add value. This focus in innovation can be said to belong to what is often referred to as user-generated or bottom-up innovation, and in many cases the innovations are incremental in nature. The climate for this kind of innovation is dependent on the culture in schools and on the professional culture of teachers. An important factor in order to enable such innovations to scale up is the availability of a culture of sharing among teachers. Development of professional communities of practice aiming at sharing resources and experiences can be important facilitating tools for this.

The pedagogical axis is heavily dependent on a coherent and available knowledge base on how technology can add value to teaching and learning. Further, the pedagogical axis can benefit from a research-based and professional discourse on whether and how technology can transform and enrich learning processes.

Technological axis

The technological axis reflects the strong importance most countries place on access to laptops, broadband internet connection, learning management systems etc. Infrastructure becomes an enabler for access and equity with regard to technology in education, as the many 1 to 1 computing initiatives around the world demonstrate. As such, infrastructure is a necessary, but not sufficient prerequisite for the advancement of technology in education.

The key and probably most important issue with regard to technology in education is that technology must not only be accessible, it must also be robust and scalable enough to tackle the needs of teachers and learners. If the infrastructure is neither available nor working, good intentions of integrating technology into teaching cannot be fulfilled. Neither available nor working, good intentions of integrating technology into teaching cannot be fulfilled. Another dimension in the domain of technology is that the need for of support services for technology and pedagogy must be catered for. A single school is in most cases not equipped with the necessary human resources to ensure a professional and cost-effective procurement. Local authorities can address this issue at some aggregated level or through collaboration between local authorities in a region. National authorities can contribute through national procurement frameworks, of which Becta is a good example.

The use of technology in schools can benefit with collaboration with other parts of education. Although the evidence is scarce, there is reason to believe that some countries have utilised some kind of trickle-down model for innovation in learning technologies through collaboration with higher education institutions and actors. In the state of Maine in the United States, the network was hosted by the University of Maine. In Norway, the solution for federated identity management now being deployed in primary and secondary education was originally developed in a higher education setting. Such innovation models should be the subject of further study.

Technology in education has centred much on laptops and netbooks. The computer has for a long time been the dominant technological artefact. That is now changing, and the educational system should prepare for a time of greater technological diversity.

The 2010 K-12 edition of the Horizon (Johnson *et al.,* 2010) report points at six emerging technologies that will impact education over the next four to five years. The technologies are:

- Cloud computing
- Collaborative environments
- Mobiles
- Educational games
- Augmented reality
- Flexible thin displays

Even if these predictions should prove to impact education in other ways and at other times than predicted, they clearly indicate some important trends related to net-based resources, the emergence of mobile and handheld devices, the incremental integration of game-based applications and the development of enriched forms of learning resources – all in all trends that will require a more robust infrastructure than most schools have today.

Knowledge axis

The knowledge axis is linked to the important role knowledge plays in innovation processes. As the background paper for the expert meeting points out, education systems need "a formalised, coherent, well-sustained and up-to-date knowledge base to increase their innovation capacity" (OECD, 2009a).

The knowledge challenge can in many ways be said to be a double or even a triple challenge. The first part of this challenge is to secure that a sufficient knowledge base is established. A knowledge base can partly be based on research and partly on experience and evidence from pedagogical practice. Some countries may still have cultural barriers towards an orientation towards what works, so-called clearinghouses, but the general impression is that the educational community sees the benefits of an updated knowledge base. In an international context, we may ask whether a knowledge base is a national or an international issue. The answer lies probably somewhere between "yes" and "no". Parts of a knowledge base on technology in education will be rooted in the context of each educational system at regional or national level and must thus be a national responsibility. Other issues are not limited to context and can be subject of international collaboration.

The second layer of the knowledge base challenge is to secure effective dissemination of knowledge. This can be regarded as a part of the pedagogical support services that should be available to teachers, *i.e.* a knowledge

infrastructure for practitioners. Different solutions may be preferred, but a key issue is to ensure that the knowledge base is structured in a meaningful way, *e.g.* aligned with the curriculum, and that it is easily accessible. This is an area where mediating agents such as national agencies can play an important role along with bottom-up initiatives such as communities of practice among teachers and school leaders.

A third layer of the knowledge challenge is the necessity of utilising the knowledge base. This layer is largely about the demand for the knowledge base and the professional culture among practitioners in education, which is a prerequisite for integrating research-based evidence into teaching and leadership. A Norwegian study from 2007 (Jensen, 2007) suggests that teachers have access to resources tailored to their needs to a lesser degree than some other professions. If this is an expression of lack of resources or lack of an orientation towards such resources within teachers' professional culture is an open question. However, if teachers are not inclined to use resources derived from research and innovation, public investments in dissemination strategies run the risk of being under-utilised.

An interesting finding from the TALIS survey (OECD 2009c) that deserves attention is that the respondents in the survey identify a high need for professional development in technology for instruction. There may be several reasons for that related to the pace of technological change, but it can also indicate a difficulty in developing the necessary capacity in technology in schools.

Policy implications

In times of economic crisis, a systemic approach to technology-based innovation in education is even more urgently needed. Most countries are now facing difficult times and OECD member states are no exception to this. The immediate programmes that many governments have launched – sometimes in a co-ordinated way, with the aim of facing the financial crisis – have also been coupled in many cases with in-depth reflection about the way in which our economies work and with strategies to promote longer-term development and vision. In the context of this reflection it becomes apparent that in the medium and long-term, innovation will increasingly be a key factor not only to economic growth but also to social welfare. The efforts to sustain technology-based innovations in education should be no exception to this. In the light of the financial crisis, each educational system should improve its ability to scale up technology-based innovation for improved learning outcome and learning strategies.

With the support of the remaining stakeholders, governments in particular may need to do the following in order to set up the conditions for such a system:

Develop a systemic approach to innovation as a guiding principle for innovation-related policies.

Such a systemic approach includes at least five basic elements:

- a clear policy intended to support research on technology in education in light of national priorities, both at policy and practitioner levels;
- an evolving framework for sustaining both top-down and bottom-up technology-based innovations, including monitoring and evaluation mechanisms which can contribute to the generation of new knowledge about policies and practices regarding technology in education;
- a unified knowledge-base which includes both research evidence and the new knowledge emerging from the assessment of innovations, including links to international knowledge bases on these topics; and
- regular efforts to synthesise and disseminate new knowledge on effective policies and practices regarding the use of technology (*e.g.* observatories or clearinghouses) as an enabler of educational innovations, in order to challenge the *status quo* of the system, set new horizons and contribute to incremental change.
- capacity building (structural, personal) to enable all the elements above.

Promote a continuous and evidence-informed dialogue about innovation with the stakeholders in the field.

Often, policy discussions about technology in education are particularly prone to biased uses of the knowledge base, particularly in view of the absence of solid empirical evidence. However, the engagement of stakeholders in policy dialogue is a requisite for successful policy interventions in view of reaching a consensus and sharing a vision which guides action. It is therefore of highest importance to inform the policy debate with evidence, provided that all stakeholders share a minimal capacity level to be able to benefit from it.

Build a well-organised, formalised, easily accessible and updated knowledge base about technology in education, as a prerequisite for successfully internalising the benefits of innovation.

In many countries the usual mechanisms (such as dedicated journals, academic journals, conferences, national reference and research centres, and the like) that would contribute to the articulation of a knowledge base are not in place. Some countries may want to address this need by using existing facilities or mechanisms while others may prefer to set up new measures as an indication of the increased priority allotted to technology-based innovation in education, such as the creation of dedicated research centres, networks or prioritised calls. The benefits of investments made in technology-based innovations will hardly be recognised and of any relevant use unless the appropriate tools for knowledge management are in place: to gather knowledge which might be usually dispersed (for instance, by different stakeholders but also from diverse sources of innovation), to cumulate in a consistent and coherent way, to articulate it in order to generate clear messages, and finally to disseminate results in decision-oriented terms both for practitioners and policy makers.

Supplement investments in technology-based innovations with the necessary efforts in monitoring and evaluation.

It is in the best interest of public governance and accountability to generate the mechanisms and procedures required to critically approach both bottom-up and top-down innovations. An empirical assessment can contribute decisively to:

- informing decisions about the scaling-up or the diffusion of innovations;
- instil in the main actors involved the culture of output-oriented innovation: innovations aimed at measurable improvements which can help when coping with innovation fatigue or resistance;
- get value for money; and
- obtain feedback on the results of particular policy measures intended to foster innovation.

Support relevant research on technology in education according to national priorities and link these efforts to innovation.

Research on technology in education is, compared to other areas of research in education, ill-served for a number of reasons. Education systems could greatly benefit from a national system of educational research on technology which combines the following elements:

- funding opportunities for researchers according to national priorities with international standards of quality;
- capacity building with the cooperation of research centres and universities, if possible in view of cooperation with international networks;
- dissemination activities, particularly by means of tailored publications, intended to engage a large range of stakeholders in the discussion of the implications of research evidence, who in some cases may require some additional capacity building; and
- setting up mechanisms for the involvement of those institutions or programmes responsible for initial and continuous teacher training.

Ensure that technology-based innovations do not reinforce existing digital divides or create new ones.

The socio-economic background of the students is an important determinant for how they succeed in education. As the report on technology use and educational performance in PISA 2006 shows (OECD, 2010a), the analysis of PISA data demonstrates that for educational performance, computer use amplifies a student's academic skills and competences, and these competences are related to the student's social, cultural and economic capital. The educational system should take this challenge seriously as access to computers and broadband internet connection has become almost universal.

Align or embed strategies for technology-based innovations with national policies for educational quality and equity.

Having a separate technology strategy for education can serve several purposes. One purpose is the signalling effect a strategy can have – a strategy signals that the domain the strategy covers is an important priority and should get the attention it deserves. On the other hand, technology in education should in order to be sustainable be well aligned with national policies and priorities for quality and equity in education. One of the reasons for this is that it will underpin the pedagogical function of technology, where technology becomes a means to an end and not an end in itself.

The road ahead

Technology has come to stay in our schools and access step by step becomes universal in most countries. What lies ahead? Rigid predtechnologyions cannot be made, but a possible route ahead can be a "hybrid" phase, in which countries and systems still will focus on technology-related issues. The pace and dynamics of technological change will probably be drivers for such a focus. At the same time the need to embed technology in policies and strategies will remain and probably grow stronger. Previous and future work of the OECD will help inform the international educational community with important insights on what constitutes effective teaching environments and strategies as well insights into the building blocks of innovative learning environments. The TALIS report (OECD, 2009c) conveys important findings with regard to the building blocks of an effective teaching environment, and a future challenge is to increase our efforts to analyse how technology can be a major contribution to such environments, thus lowering the threshold some teachers experience with regard to using technology in their teaching.

Another area that deserves attention is the relationship between public service and the formal system of schooling on the one hand and other stakeholders, such as non-formal schooling and private sector actors on the other hand. The Lumiar case from Brazil is a powerful expression of how the traditional system of schooling is challenges, and the formal education system should be open to innovations coming from "outside of the family". Public service and government should be aware of the important role it has to play as an engine for innovation. The OECD report on measurement of innovation (OECD, 2010b) points to for instance a high level of readiness to develop and implement e-government services as a factor for an innovative public sector.

A third area for further debate is the need to analyse the drivers of emerging technological artefacts, especially with regard to underlying motives of such phenomena. Selwyn (Selwyn, 2009) offers a critical perspective to the emergence of Web 2.0 applications and the hype surrounding their uptake in education. As Selwyn points out, one of the drivers for this attention seems to be actors with a deschooling agenda.

It has been said that no man is an island. This is also true when it comes to technology-based innovation in education. No actor or group of stakeholders can secure success and sustainability in this domain by themselves. Only through collaboration within education, between education and industry, and between education and other parts of public service, can we secure success for the benefit of all learners.

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