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ICT in Primary Education

Analytical survey

Volume 1
Exploring the origins, settings and initiatives

UNESCO Institute for Information Technologies in Education

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We would also like to acknowledge Prof. Diana Laurillard for final text editing, Prof. Valentina Dagiene and Prof. Maciej M. Sysło for the peer review and positive response on our publication.

Bellow is the list of our initial sample of innovative primary schools which we worked with during the first year of the project. They are listed in alphabetical order by country.

S1	Hungary	Budapest	ELTE Gusztáv Bárczi SEN Practicing Elementary School 1071 Budapest, Damjanich utca 41-43. Headmaster: Papházy Éva barczigyakorlo.elte.hu gyakiskola@barczi.hu
S2	Jordan	Amman	Princess Rahma Bint Al Hassan School Principal: Mrs. Rana Asfour Asfour_r@hotmail.com Asfour_r@yahoo.com
S3	Mexico	Monterrey	American Institute of Monterrey Perseverancia 100 Colonia Balcones del Valle San Pedro Garza-Garcia N.L. México 66220 Principal: Elizabet W. de Huergo www.aim-net.mx ehuergo@aim-net.mx
S4	Russian Federation	Moscow	Technology of Education Centre Principal: Mr.Yezdov Alexander www.home-edu.ru ischool@i.home-edu.ru
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S6	Slovakia	Lieskovec	Základná škola stredisková 2735/5 Lieskovec Headmaster: Mgr. Katarína Valocková www.zslieskovec.edu.sk zwkladns@zslieskovec.edu.sk
S7	South Africa	Bloemfontein	St Andrew's School for Boys Headmaster: Mr. Christopher Thomas www.sasb.co.za jennydg@sasb.co.za
S8	UK	Richmond, London	St Richards CE Primary School Ashburnham Road Ham Richmond TW10 7NL, UK Headteacher: Ms. Carmen Palmer www.srsa.richmond.sch.uk info@srsa.richmond.sch.uk
S9	USA	Arlington, VA	Jamestown Elementary School 3700 N. Delaware Street Arlington, VA 22207 Principal: Kenwyn Schaffner Instructional Technology Coordinator: Camilla Gagliolo www.apsva.us/jamestown

The first column contains the school reference codes which we will use throughout the whole study.

All visual materials and photographs are reproduced with the consent of the cooperating schools, which also obtained permissions from the parents of the pictured children.

A Small Island City Connected to a BIG BIG WORLD, S5

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Foreword

In 2011 the UNESCO Institute for Information Technologies in Education (IITE) launched a new project which is focused on the role of information and communication technologies (ICTs) in primary education. The aim of the IITE project "ICTs in primary education" is to facilitate the policy dialogue and build a foundation for effective primary education through ICT usage.

Primary education is the largest sub-sector of any education system and offers the unique opportunity to contribute to the transformation of societies through education of the young. In order for young people to adjust to and compete in the rapidly changing environment of the contemporary world they need to have a set of life skills which includes among others, communication, analytical and problem-solving skills for creativity, flexibility, mobility and entrepreneurship. Thus an educational strategy should be oriented on the new lifestyle concept and corresponding skills development alongside technological innovations.

UNESCO is at the forefront of activities concerned with redefining educational paradigms to meet the needs of modern society. In particular, new approaches to education give an important role to the use of ICTs, the redrafting of curricula, a greater focus on skills and the training of a new generation of teachers.

This analytical study includes a research literature review, a brief overview of the nine sample primary schools, an international review of various ICTs in primary strategies, and also an international collection of inspiring projects and initiatives.

This publication was elaborated by IITE expert team members – professionals from various regions of the world (Chile, Jordan, Hong Kong, Hungary, Slovak Republic, South Africa, Russian Federation, UK and USA). I want to express my gratitude to Professor Ivan Kalaš – project team leader for the significant efforts and leadership to build the expert team and to coordinate the project activities. Let me also sincerely thank all members of IITE project team for our fruitful collaboration and their significant contributions.

Let me express my hope that this publication will help the educators in recognizing new educational paradigms and will allow them to generate new methods to unlock the potential of ICTs in primary education. I wish you success in your important work!

Dendev Badarch,
UNESCO IITE Director a.i.

Executive summary

The UNESCO Institute for Information Technologies in Education (IITE)[1] focuses on **making the best use of the educational potential of ICT** by facilitating a corresponding policy dialogue and promoting capacity development through international networking and collaboration. In its activities, IITE initiates various studies about possible and actual roles of ICT at school. In 2010 IITE conducted an analytical survey about the integration of ICT into early childhood formal education. Its findings[2] have been well accepted by practitioners and policy-makers. When we consider the potential of new technologies to support the development, learning and play of pre-primary children with such achievements as reported in the study, it becomes natural and necessary to explore similar phenomena in the successive level of formal schooling – in primary education.

Therefore, in 2011 IITE established an international team of nine UNESCO experts with the goal of conducting a long-term study on **how ICT is reshaping the teaching and learning processes of children in primary education**.

Research literature and experience from many school-based projects prove that the environment of primary education supports innovation and transition to modern, playful and exploratory learning remarkably well. One of the reasons is that, for each class, most subjects are typically taught by the same teacher. This creates opportunities for the complex integration of ICT across subjects and facilitates the emergence of meaningful new pedagogies.

Analyzing the changes in the teaching and learning processes in primary education that are due to the integration of ICT is a real challenge: there are many different factors, strategies, and approaches, as well as positive and negative experiences to examine. Through our work we decided to support primary teachers and school policy-makers in all countries and regions by developing a better understanding of the process they go through while either trying to initiate or promote ICT further in their schools. As the goals of our project we determined to:

- collect, analyze and document local idiosyncrasies and shared approaches to the complex process of integrating ICT in primary children's learning experiences;
- demonstrate why governments should invest in integrating ICT into the learning processes of children and why many of them do so;
- investigate the reasons why teachers and leaders use ICT in their everyday pedagogy and what for and, especially, why they should use it in primary education;
- study the roles of teachers, children, parents and school leaders in this process;
- study and document the opportunities provided by ICT for teaching and learning (supporting the development of literacy, numeracy, science, 21st century skills, etc. in primary schools);
- collect and share a range of learning outcomes, identifying learning outcomes that may be planned for and expected in this context;
- disseminate the experiences of a group of leading primary schools which IITE will collaborate with during the project;
- examine the limitations of ICT and the associated concerns in primary education.

[1] *iite.unesco.org*
[2] see (Kalaš, 2010)

The project was planned over several years. We launched it in 2011 by identifying and working with nine outstanding and innovative primary schools from different countries around the world. In the second year of the project this focused sample will be extended to several dozen schools that will be involved in the project as a source of qualitative data for our study. In this report, which is the outcome of the first year of the project, we applied the following instruments for our research:

- selecting an initial sample of leading innovative primary schools and initiating an intensive communication with them; presenting their profiles in terms of ICT and teaching/learning processes;
- analyzing a variety of national approaches to ICT in education;
- studying and reviewing research literature and interesting initiatives in the field of bringing new technologies into the teaching and learning processes of 21st century learners, and sharing inspiring findings and interesting observations with our audience;
- exploiting the personal knowledge of the members of the expert team, profiting from our engagement in various international networks, institutions, initiatives and projects, and mediating this accumulated and integrated experience to an audience of teachers, principals and school policy-makers.

This report constitutes the introductory part of an intended analytical study. In this report we map the premises for the study and explore how the idea of ICT in primary education emerged historically, how it is at present being implemented in various national ICT strategy documents and how different institutions react to it. We structured the report into six chapters, Chapter 1 being an introduction.

Historical, cultural and educational background

In Chapter 2 we examine the reasons that call for and stimulate **substantial changes in formal education** – in the context of the *knowledge age* and the transformed world of work. We explore the historical roots of the views that have pointed to the outstanding potential of digital technologies to support these changes and to enhance new and different learning processes of our pupils.

Nowadays, new forms of ICT presence in education are frequently discussed, observed, studied, called for or warned against. We are slowly growing out of early, sometimes naive concepts of the role of ICT in education, which often promised too much. Instead, a more consolidated view is being adopted: the perception of ICT as a tool for learning, communication and self-expression, productively and carefully integrated into our learning, work and leisure.

The above-mentioned transitions concern every level of education, from early childhood, primary and secondary, to higher and adult – including professional in-service development of teachers. And yet, among all these levels – as proven by several recent research findings – early childhood and primary education are the most formative stages. That is the reason why in this chapter we examine the **historical, educational and cultural connections behind the phenomenon of ICT in primary education**. We are seeking the answers to the following questions: *Where and when did the idea of computers in the hands of children – as a tool for better learning, for discovering powerful ideas by themselves – come from? What is the educational context and imperative around having children develop new ways of knowing and new skills for the 21st century? How can schools in different countries and regions respond to this imperative while respecting their cultural and religious norms? What are the different models for the presence of ICT in primary education?*

Figure 1 Kinect kids – eager to engage through the use of games and technology, S7

What does the research literature say about ICT in primary education

In the last two decades, governments and educators all around the world have recognised or are coming to recognise the exceptional promise of ICT to foster teaching and learning in primary schools. However, it is important to note that for ICT to enhance teaching and learning, it needs to be supported by education and school policies and effective professional development for teachers. Therefore, Chapter 3 draws upon existing **research and evaluation publications** on how ICT has been used successfully in schools to enhance students' learning outcomes, or has not been successful, and identifies the conditions that support or hinder these ICT-mediated teaching and learning practices.

In this chapter we study how the recent research literature answers the questions: *Which opportunities are provided by ICT for teaching and learning in primary schools in literacy, numeracy, science, and 21st century competencies? What are the limitations of ICT and associated concerns in primary schools? What are the roles of teachers in ICT-enhanced teaching and learning in primary schools? What are necessary and sufficient conditions to support the ICT-enhanced teaching and learning practices in primary schools?*

Vignettes of innovative primary schools

For the purposes of our study we are interested in processes and transitions that are happening in a sample of exceptional primary schools. We consider their objectives, the relations among all the actors, and in the content, values, attitudes and strategies they apply to make the transition happen. Therefore, we started our project by identifying and engaging with nine outstanding primary schools, from nine countries on four different continents. Throughout the project we have worked intensively with them, learning from them and observing their practices. In Chapter 4 of this report we present our first contact with them, in which they briefly introduce themselves and characterize their position on ICT.

Each of these nine schools represents an exciting, unique and enlightening story. They cover a range of contrasting contexts: there are urban schools and rural schools, one very small school and some rather large, a school with only primary level classes, a school with excellent cooperation with a kindergarten, schools which prioritize excellent relations with parents, with academia or with a private partner, and a school that concentrates on activities for children with special educational needs.

We asked the contact teachers of these schools to provide us with additional visual material to enhance all the chapters of this report. We present various products of the pupils' expressions of themselves as users of digital technologies, or photographs documenting how they exploit those technologies – inside their classrooms or outside, using computers, robots, digital cameras, etc. Additionally, we asked the pupils to express visually their relationship to ICT by elaborating on a theme of *Computers and Me*. Their answers can be found throughout this report.

In the next part of our study we will extend our initial sample to several dozen inventive primary schools from all around the world – representing different cultures, traditions, approaches, and different platforms for innovation. In extensive communication with them we plan to get inspiring and representative data for further qualitative research about **how ICT is reshaping the teaching and learning processes of children in primary education**.

Figure 2 Computers and Me by Jual Pablo (age 10), S3

National approaches to ICT in education

In Chapter 5 – supplemented by Appendix 1 – we set out the principles that are common to most of the national strategies for ICT in education documents, **identify some of the most interesting approaches to fostering the use of ICT in primary education**, summarise the essential points in a selection of national documents, and present selected quotes from these documents.

The information reported in this chapter has been collected from national government websites that publish statements about educational approaches. We have selected a representative choice from all parts of the world. We summarise the information extracted in terms of *(i) the agencies involved in development and delivery of the policy; (ii) the government-driven initiatives deployed to promote change; (iii) the approach to ICT in the curriculum; (iv) the digital tools, resources and services made available to education; and (v) the approach to teacher development with respect to the use of ICT for teaching and learning.*

In some countries we have been able to identify evaluation reports of previous strategies and initiatives. However, there are often no specific evaluations carried out. The extent to which these strategies have borne fruit is hard to assess, therefore. What we can conclude reliably is that there is a clear intention, by a wide range of governments, **to establish ICT as a critical part of their programme to improve and update primary education**.

Inspiring national and international initiatives and projects

Chapter 6 presents a rich selection of different national and international initiatives, networks, and projects that have been or are being successfully implemented and could be of value to either **join, or re-interpret and scale to other educational environments and conditions**. Although not all of the selected examples are exclusively addressed to primary education, the overarching aim of our presentation is to provide sparks of inspiration out of real world experiences that might resonate with the reader's own needs and context.

These national and international initiatives and projects usually result from situations where a personality or an organization, commercial company or institution – private, public or non-profit, regional, national, international or global – articulates a certain strategy, policy or vision and implements it as an opportunity for schools, school leaders, school teachers, students, regions, or communities to **harness the potential of ICT for development and innovation**. If such an organization is a government – and this is not its official national policy – it typically acts as one of the partners who jointly put their vision into operation.

For each project or initiative explored in our report we anticipate and expect that it places direct or indirect **focus on ICT** in (primary) education innovation, (primary) teachers' development, or school networks, focuses on practical implementation and not only on policy statement, promotes 21st century skills and digital citizenship, and has already had some **impact in terms of new digital pedagogies**, digital teaching and learning resources, scope (national or regional), perceptions of benefits, powerful partnership, or geographical or cultural relevance.

In the six chapters of this report we have explored the historical and cultural background of the phenomenon of ICT in primary education, actual knowledge of the topic presented by the research literature, various interesting national policies and the most interesting governmental strategies for fostering the use of ICT at school. We have presented an initial sample of our innovative schools and also a rich selection of inspiring national and international initiatives, networks, and projects that could be of value to either join or to use as an inspiration for projects working under different educational conditions. This initial set-up provides the conceptual framework for our whole project and its further outcomes.

During the next step of our study we will focus on the practicalities of ICT use in primary education – based on reports from the extended sample of schools, and enhanced by the extensive experience of the expert team members and findings from the latest national and international research projects. We will consider categories of ICT deployed in the learning process, the organization and forms of activities, the management process and teachers' professional development, and will present the best practices from the different cultural and socioeconomic contexts of our sample schools.

Studying and analyses of the international experience will allow us to develop corresponding recommendations for the process of integrating ICT into teaching/learning processes in primary education, the strategies and outlines of professional primary teacher development programs, and reflections on future developments and trends in this issue. We will also explore connections (in the area of integrating ICT) between early childhood and primary education, and also between primary and secondary education.

We believe that this report and the forthcoming volumes and other project materials will inspire teachers to work together on exploring ways of using ICT for themselves,

and will give them some of the support they need to learn from the work of other teachers. We also believe that the lessons documented from the existing local, regional, national and international initiatives will give policy-makers a secure and qualified basis for the planning of future initiatives that will use ICT to transform primary education throughout the world, as we aim to meet the UN Millenium Development Goals.

Figure 3 The computer as one of many exciting things around us, S6

1 Introduction

The UNESCO Institute for Information Technologies in Education (IITE)[3], focuses on **making the best use of the educational potential of ICT** by facilitating policy dialogue and promoting capacity development through international networking and collaboration. In its activities, IITE initiates various studies about the possible and actual roles of ICT at school. Thus, in 2011 an international team of nine UNESCO experts was established to: *work for 3 years to analyze different approaches, priorities, obstacles and strategies, and articulate recommendations for integrating ICT into everyday work and play of our primary children and their teachers.*

This project corresponds with previous related studies initiated by the Institute. In 2010, IITE conducted an analytical survey about the integration of ICT into early childhood education. Its findings[4] have been well accepted by practitioners and policy-makers. When we consider the potential of new technologies to support the development, learning and play of pre-primary children as reported in that study, it was desirable and necessary to explore developments in the successive level of formal schooling – in primary education.

Indeed, the issue of ICT in primary education had already been studied by IITE approximately ten years ago, in cooperation with the International Federation for Information Processing (IFIP) and the Institute of New Technologies in Education (INT); see (Informatics for Primary Education, 2000). Those authors reported as follows:

> *These Recommendations are aimed at providing a source of information about the state of the art in the informatization of primary education; another goal is to outline the trends in the field, presenting some ideas useful in the long-term outlook. The ever-increasing speed of technological progress makes our somewhat ambitious goals even more difficult to achieve. We need an even broader perspective in order to plan educational strategies, which rely so heavily on the information and communication technologies of today and tomorrow. The fact that ICT and education are evolving at different tempos is very relevant for our considerations.*
>
> *Informatics for Primary Education (2000 : 6)*

While these goals remain appropriate, many external conditions have considerably altered during the past decade. Most of all, the children which we were thinking about 10 or 15 years ago, are adults already and are becoming parents of children who are or will soon be pupils of today's primary schools. New technologies have appeared, for example mobile digital devices, which are often in the pockets of our pupils[5]. The dramatically altered accessibility of ICT to young people, in school and at home, has introduced new options and new problems; better attitudes to ICT and better computer literacy of teachers, parents, and the general public has been achieved; the necessity to transform schools, increasing respect for the needs of 21st century learners, and many other relatively new topics are being discussed regularly; many more research

[3] *iite.unesco.org*
[4] see (Kalaš, 2010)
[5] of course, this is at present only true for children in a few countries.

projects[6] in the area of ICT in (primary) education are being conducted with instructive findings, clarifying important aspects and reporting on various successes and failures. These are helping us better understand how children learn and live in the digital world, and to respect more carefully their individual needs and personal learning styles.

Politicians and many governments have become better aware of the potential of ICT in primary education and in several cases have already projected such new attitudes into official national strategy documents, and sometimes also into national curricula. Moreover, there is a wide range of recent national and international projects and initiatives for schools, teachers and students engaging with ICT in education. ICT has widely spread and is being exploited in many schools. There is so much we can learn from practical experience, so much to analyse, evaluate and compare. The researchers and academics should respect the rich innovative experiences of those schools, offer them support to share with other schools, and support the sharing of professional expertise among teachers.

At many primary schools exciting things are happening. This is how L. Conery, one of the authors of this report, commented after a visit to one school:

> *I wish I could figure out how to capture the spirit of what a primary teacher <name> is doing in our book. She doesn't do robotics and I haven't seen her use digital microscopes (if she had one she'd be brilliant!) but she does all the rest. It's amazing! The class goes for walks in the wood. They count things, blog about their experiences and what they are learning, photograph it, create video…*

In our present project we want to take all these new factors into account, we want to carefully consider the latest research findings and thoroughly analyze the current government and non-government ICT initiatives. Most of all, at the very beginning of the project we established an initial sample of outstanding primary schools and are pursuing an intensive dialogue with them. We plan to extend our sample to several dozen in the second year, and to make the most of the rich qualitative data that these schools offer us.

Figure 1.1 This is my dog, S1

[6] but still by far there are not enough to properly understand what is happening.

This is the digital generation

One of the most significant changes over the past decade is this: at primary school we nowadays deal with children of the *digital or net generation*, that is, with children that were born into a world where breath-taking digital technologies have become commonplace – the Internet, smart phones, mobile learning, social networks etc. Many educators are taking the view that changing external conditions give us no alternative: we are obliged to deeply rethink and reconsider schooling, and the goals of education.

As noted by Trilling and Fadel (2009), four powerful forces are converging and leading us toward new ways of learning for life in the 21st century:

- **knowledge work** – increasing demand for knowledge workers and innovators that businesses need to be successful in the knowledge economy of today;
- **thinking tools** – new technology, devices and services that comprise a knowledge worker's equipment;
- **digital lifestyles** – different ways of delivering, watching, hearing, entertaining, communicating or solving everyday problems. Thus, *new ways to make learning interactive, personalized, collaborative, creative, and innovative are needed to engage*[7] net generation children to be actively learning in schools;
- **learning research** – our recent better understanding of how people learn.

As Trilling and Fadel put it, these four forces are simultaneously creating the need for new forms of learning, and also supplying the tools, environments, and guiding principles required to support new learning practices. There are also plenty of serious anxieties and criticisms. D. Tapscott (2009 : 3) presents a list of the most frequently argued issues of concern, including several references to strong critics. One of these, M. Baurlein (2008 : 201) has written:

> *The twenty-first-century teen, connected and multitasked, autonomous yet peer-mindful, makes no great leap forward in human intelligence, global thinking, or netizen-ship. Young users have learned a thousand new things, no doubt. They upload and download, surf and chat, post and design, but they haven't learned to analyze a complex text, store facts in their heads, comprehend a foreign policy decision, take lessons from history, or spell correctly.*

However, as Tapscott (2009 : 127) reasons, net generation students.

> *... need a different form of education. It's not what you know that counts anymore; it's what you can learn... Students need to be able to think creatively, critically, and collaboratively; to master the "basics" and excel in reading, math, science, and information literacy, and respond to opportunities and challenges with speed, agility, and innovation. Students need to expand their knowledge beyond the doors of their local community to become responsible and contributing global citizens.*

In our study we will pay close attention to these concerns and how schools react to them, mostly in the later volumes to be published.

[7] see Trilling and Fadel (2009 : 30)

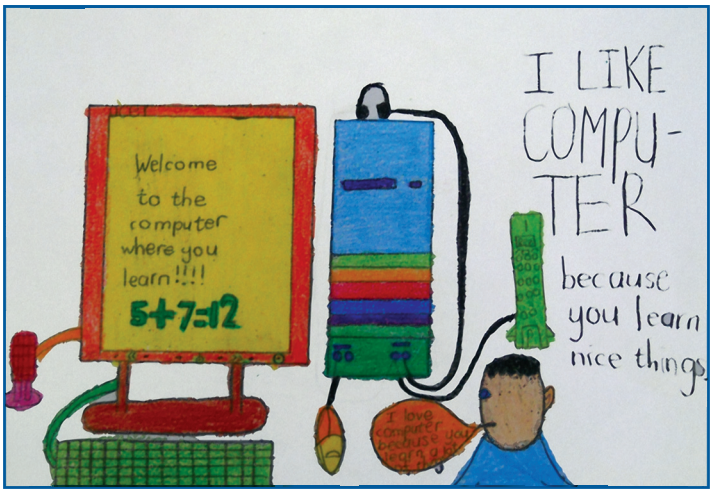

Figure 1.2 I like computer because you learn nice things! S7

Goals of the study

Analyzing changes in the teaching and learning processes in primary education due to integration of ICT is a challenge with manifold aspects, factors, strategies, and approaches – and its own successes and failures. Through the project we have listened to and observed primary teachers and school policy-makers in many countries to learn more about the process. Our goals have been to:

- collect, analyze and share the different peculiarities and aspects of the complex process of integrating ICT in primary children's learning experiences;
- study the roles of teachers, children, parents and school leaders in this process;
- collect a range of learning practices and learning outcomes that are being perceived, and identify learning outcomes that may be planned for and expected;
- study and document the opportunities provided by ICT for teaching and learning (supporting the development of literacy, numeracy, scientific understanding, 21st century competencies, etc.) in primary schools;
- study and share reasons why teachers and leaders should use ICT in their everyday pedagogy and what especially is the contribution to primary education;
- study and show why governments should invest in integrating ICT into education, and how they are already doing this;
- document and spread the experiences of our project sample schools;
- examine the limitations of ICT and the associated concerns in primary education.

Primary education and ICT

Two of the most fundamental concepts of our study are *primary education* and *ICT (i.e. Information and Communication Technology).* Both of these are common terms in every education system, however their scope and interpretation is not identical everywhere. Therefore we find it important to briefly discuss their meanings.

Primary education (according to UNESCO ISCED classification)

Primary education (ISCED 1) usually begins at ages five, six or seven and lasts for four to six years (the modal value for OECD countries being six years). Programmes at the primary level generally require no previous formal education, although it is becoming increasingly common for children to have attended a pre-primary programme before entering primary education.

The boundary between pre-primary and primary education is typically the beginning of the systematic studies characteristic of primary education, e.g., reading, writing and mathematics. It is common, however, for children to begin learning basic literacy and numeracy skills at the pre-primary level.

Source: stats.oecd.org/glossary/detail.asp?ID=5411

A strong characteristic feature of primary education in many countries is that most subjects are taught by the same teacher for each class. According to the view of experienced practitioners themselves, such an arrangement affords exceptional challenges and opportunities.

After clarifying two key concepts for our project let us remind once more what is the main focus for the study: we want to document how diverse and enriching is

What is ICT

ICT is commonly used as an umbrella term for a wide collection of computer-based instruments, resources, environments, procedures, and skills used for obtaining, processing, and communicating information.

*Note however that ICT – particularly in the context of education – is often perceived from two sides: technology as an **information medium**, and technology as a **construction medium**. As Papert (1999) points out, education itself has two perspectives that could also be called **informational** (getting information and skills) and **constructional** (creating, discovering, constructing knowledge). Although both sides are equally important, the constructional side is sometimes undervalued. Therefore, more and more authors use the term **digital technologies** instead of ICT to emphasize the need for balance between the informational and constructional sides. In our study we adopt a broad sense that includes both informational and constructional sides, and we regard ICT and digital technologies as synonymous terms.*

*Thus, by **ICT** we refer to a collection of computer-based technologies, which are exploited to support teaching and learning, communication and collaboration, self-expression, creation, etc., that is, for the promotion of all developmental domains of children, and learners of any age.*

the presence of ICT in primary education – ranging from the role of **technology for better instruction,** through **tools for creative self-expression,** to **support of children's learning and thinking processes, special educational needs,** to **educational robotics,** and **programming for children**.

The intended audience for this study

With this study we want to address primary teachers and educators in all regions around the world, headteachers, school policy-makers and decision-makers, and ultimately everybody who cares about modern education for primary children.

Those of our readers who are only at the initial stage of integrating ICT into primary education, may through the series of reports presented here acquire a detailed picture about the various aspects of the integration process, about the reasons for using ICT, and strategies for how to minimise problems or avoid them at all. They will learn about many opportunities that exist to get involved in different national and international projects and initiatives. Readers who are experienced practitioners may get valuable inspiration from the collection of best practices we present. Moreover, all of the findings from our sample schools are supplemented by the recent knowledge that is available in the research and other academic literature.

Figure 1.3 Two girls working with an iPad, S9

Instruments, strategy and anticipated outcomes

We decided to use the following instruments for accomplishing the goals of our project:

- to select a worldwide sample of leading innovative primary schools – in various senses – and to conduct detailed qualitative analyses of the data collected through intensive communication with them;
- to address not only principals and teachers in the sample schools but the pupils as well, so that we could learn directly about their attitudes and experiences[8];
- to study the research literature and ongoing interesting initiatives internationally, and to share inspiring findings and interesting observations with our audience;
- to summarise and explain different interesting curricular strategies;
- to exploit the personal knowledge of the members of the expert team, profiting from their engagement in various international networks, institutions, initiatives and projects, and to digest this accumulation of experience for the benefit of teachers, principals and policy-makers.

Innovative sample schools

The key source of information for our study comes from the sample of innovative primary schools. In the first year of the project we have cooperated with nine schools, from nine different countries and diverse cultural backgrounds. In the next year, we will extend the sample to around 40 schools. We have looked for schools that have a particularly enlightening story to tell, which illustrates transitions in the "traditional mindset", everyday pedagogies, learning goals, and the relationships among all the types of people involved.

Our sample schools are helping us collect inspiring case studies, stimulating examples of promising practice that other schools anywhere around the world could benefit from – by trying to emulate their outcomes in learning, understand different aspects and problems of the transition, and to strive to avoid their failures.

Outcomes of the study

We want to address our audience in language that is understandable to primary practitioners, and available both in electronic and printed formats, using the *iite*. *unesco.org* website and through a series of tpublications. A project web portal will support schools from everywhere to communicate, learn from each other and share their own experiences.

The current publication (Volume 1) explores the historical background, and sets the scene for ICT as a means to support the development and learning processes of children in formal primary education. It presents a research literature review, profiles of the first nine sample schools, an international review of various interesting ICT in primary strategies and curricular documents, and an international collection of inspiring projects and initiatives.

The next step of the project activities will be focused on the practicalities of ICT use in primary education. This will be based on reports from the extended sample of schools, and enhanced by the extensive experience of the expert team members, and findings from the latest national and international research. We will consider

[8] Some of the personal expressions of the pupils appear throughout this report, in words and pictures.

categories of ICT deployed in the learning process, the organization and forms of activities, the management process and teachers' professional development, and will present the best practices from the different cultural and socioeconomic contexts of our sample schools.

The following step of the project – and a new publication – will offer an overview of our research findings and corresponding recommendations for the integration of ICT into teaching and learning processes in primary education; strategies and outlines for professional primary teacher development programs; and reflections on future developments and trends. We will also explore the connections, in the context of integration of ICT, between early childhood education and primary education, and between primary and lower secondary education.

About the authors

Each member of our expert team has rich experience in the field of integrating ICT into primary education, and related educational research. We also have extensive experience of collaboration with governments, schools, academia and private partners. We represent different regions and diverse cultural and educational backgrounds – coming from Chile, Hong Kong, Hungary, Jordan, Russian Federation, Slovakia, South Africa, UK and USA – and different institutions, networks and programs – including IITE, the academic domain, IFIP[9], ISTE[10], Microsoft Partners in Learning program, and others. Each expert is also actively engaged in the process of transition and innovation of education in their own country.

We are aware of the fact that the issue of *ICT in education* – on any level, from early childhood, through primary and secondary, to higher education and lifelong learning, is much debated and the subject of numerous previous projects and reports. Nevertheless, we believe that the collective experience of our team, and the intensive engagement with teachers and children in our worldwide school sample, will generate some unique, interesting and inspiring findings, well representing the actual positions of the members of the UNESCO IITE.

ICT in primary education is a particularly vivid and turbulent area of knowledge, skills and attitudes – not only because of the rapid advance in the field of ICT itself, but also due to the maturing understanding and accumulating experience of school leaders and managers, teachers, pupils and their parents, and researchers. By learning from these, we all can increasingly better identify the priorities, problems and challenges that we have to face.

[9] International Federation for Information Processing, see *www.ifip.org*
[10] International Society for Technology in Education, see *www.iste.org*

2 Historical, cultural and educational background

The expectations and requirements of **society and the world of work** are undergoing fundamental transformations, as rightly observed by Trilling and Fadel:

> *The 21st century has already brought historic changes to the world of work. The Knowledge Age demands a steady supply of well-trained workers – workers using brainpower and digital tools to apply well-honed knowledge skills to their daily work.*
>
> *Today's knowledge work is done collaboratively in teams, with team members often spread across multiple locations, using a digital zoo of devices and services to coordinate their project work…*
>
> *B. Trilling and C. Fadel (2009 :24)*

More and more we are aware of the importance of new skills for the 21st century and new perceptions about literacy – digital and media literacy being its natural components. Society and social relations are becoming more globalized ("global citizenship"), and the growth of concern about ecology and sustainable development (in reaction to human-induced climate change) is another significant factor for social and political change.

There is a growing agreement that these transitions in the social world should be the cause for substantial changes in formal education. Various forms of ICT in education are frequently discussed, observed, studied, called for, or warned against. The potential of ICT to support the learning processes of children, students and teachers is being studied. We are slowly growing out of early, sometimes naive conceptions of the role of ICT in education, often promising too much. Instead, a more consolidated view is being adopted: the perception of ICT as a tool for learning, communication and self-expression, productively and carefully integrated into our learning, work and leisure.

Every level of education, from early childhood, primary and secondary, to higher and adult – including professional in-service development of teachers, is affected by the above-mentioned transitions. And yet, among all these levels – as proven by several recent research findings – early childhood and primary education are the most formative stages. As noted by J. Heckman (2010): *the early years in the life of a child are sensitive periods for the production of cognitive skills, and the adolescent years are sensitive periods for the production of non-cognitive skills. Later remediation for early disadvantage is costly and often ineffective*[11].

It was for this reason that we decided to focus this project on primary education[12] and on ICT as a means of fostering new learning and new pedagogies. However, if we want to study and understand this phenomenon, we also need to understand how it was initiated, what are the historical, educational and cultural contexts behind it, what shapes its actual state, what are the present forms of ICT in primary education, etc.

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[11] James Heckman is a Nobel Prize winner and Professor of Economics at the University of Chicago; these are excerpts from an interview with him on the occasion of the World Conference on Early Childhood Care and Education, Moscow, 27-29 September, 2010, see *www.unesco.org/new/en/world-conference-on-ecce/single-view/news/interview_with_professor_james_heckman_noted_scholar_and_nobel_prize_winner/*

[12] as mentioned earlier, this project is a follow-up to a previous IITE study devoted to analyzing the potential of ICT in early childhood education, see (Kalaš, 2010)

These are the topics for this chapter. We divided it into four sections. In the first, we study the historical connections: *Where and when did the idea of computers in the hands of children – as a tool for better learning, for discovering powerful ideas*[13] *by themselves – come from?* In the second section we will seek the answer to the question: *What is the educational context and imperative around having children develop new ways of knowing and new skills for the 21st century?* In the third section we consider: *Whether and how schools in different countries and regions respond to this imperative whilst respecting their cultural and religious norms?* In the last section, we will reflect on: *What are the different models for the presence of ICT in primary education?*

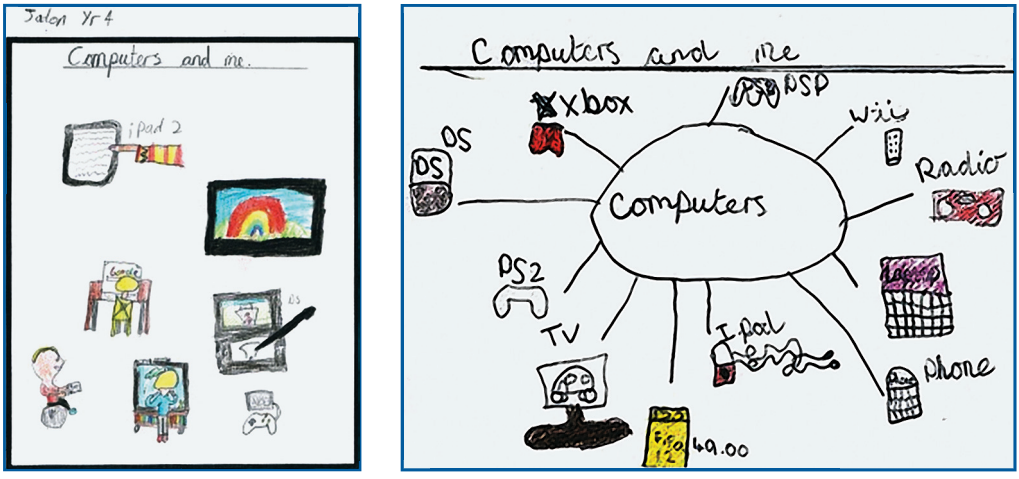

Figure 2.1 Computers and me by Zadon (age 8, at left) and by Chloe (age 8, at right), both from S8

[13] The concept of computers being exploited by children to *discover powerful ideas* is attributed to S. Papert (1980).

2.1 ICT for children: the dawn of the idea

The integration of ICT into education has developed in different ways in different countries and regions, at different times – sometimes starting at the upper secondary level and spreading downwards through the lower secondary to primary to early childhood education; sometimes at the primary level spreading both upwards and downwards; sometimes through the establishment of Computer Science or Informatics or ICT as a school subject, which then broadens out to affect other subjects and other teachers.

In this section we will address the *historical efforts* to bring ICT into (primary) classrooms to develop powerful thinking and learning skills. When doing this it is natural to refer to the pioneering work of the so-called *Logo culture and constructionist movement* [14].

From the early 1960s, Wallace Feurzeig was a leading researcher in the field of Artificial Intelligence, engaged in natural language understanding, theorem proving and robot automated problem solving. He joined the BBN laboratory (Bolt, Beranek and Newman, in Cambridge, Massachusetts) in 1962 where he collaborated with such authorities of Computer Science as Minsky, McCarthy, and Seymour Papert who had recently arrived at MIT from Jean Piaget's Institute in Geneva. Trying to expand the intellectual capabilities of artificial *teaching systems*, in 1965 Feurzeig established the BBN Educational Technology Department to *develop computer methods for improving learning and teaching*.

Thus began an effort to *develop programming languages as educational environments*, an effort which still continues 50 years later. Feurzeig, Papert, Bobrow, Grant and Solomon, came up with the idea of a **high-level conversational[15] programming language specifically designed for children**. Existing computer languages were ill-suited for educational applications, many[16] *lacked procedural constructs, most had no facilities for well-developed and articulate debugging, diagnostic, and editing means, essential for educational applications (Feurzeig, 2007)*. These considerations led to the development of Logo in 1966[17].

> *It was designed very specifically to be a powerfully expressive yet readily accessible language for construction, exploration, and investigation of ideas and processes in math, science, language, and music – to give children a lively learning environment… Our intent was that work with Logo would help kids learn to think more strategically, not only in mathematics but in other subject areas as well, that it would help them become actively involved in constructing knowledge, not merely taking it in from outside… I named the new language Logo from the Greek λογοσ, "the word or form which expresses a thought; also the thought itself." Everyone concurred.*
>
> *(Feurzeig, 2007)*

From September 1968 through 1969, the NSF[18] supported the first intensive programme of experimental teaching of Logo-based mathematics in primary and lower secondary classrooms[19]. Note that at that time, almost **nobody outside the research team believed that computers and computer programming had any**

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[14] to be distiguished from a *constructivist approach* to learning, see (Papert, 1999)
[15] today we would say 'interactive'
[16] such as the then recently-developed BASIC language
[17] The first document on Logo was published at BBN in August 1967 as a technical memorandum titled *The Logo System: Preliminary Manual*.
[18] The US National Science Foundation
[19] that is, at the levels of ISCED 1 and ISCED 2

relevance for early education. Let us summarise the research report of the first fifteen months of the project (see Feurzeig et al., 1969), combined with vivid memories of its main author from (2007):

- *Failure to obtain quick learning in classroom is not in itself an indication of the quantity or difficulty of what has to be learned. It can be an indication that the teaching method is inadequate. In fact, the guiding thought of <our study> is the conjecture that current teaching does not even attempt to identify and teach those skills, concepts, and facts most needed by the child. (1969 : 4)*
- *The computer can be used as a mathematical laboratory to foster an experimental approach toward solving problems. (1969 : 10)*
- *Solving a mathematical problem is a **process of construction**. The activity of programming a computer is uniquely well suited to transmitting this idea. The image we would like to convey could, roughly speaking, be described thus: A solution to a problem is to be built according to a preconceived, but modifiable, plan, out of parts which might also be used in building other solutions to the same or other problems. A partial, or incorrect, solution is a useful object. (1969 : 14)*
- *(Our research work with very young children) was conducted at the Emerson Elementary School in Newton, Massachusetts. We installed a single computer terminal there at the end of January 1969[20] . The school chose the children who were to participate in the study. These comprised, for the most part, mathematically "average" children whose ages ranged from seven through nine. (1969 : 31)*
- *Our intent was not to teach programming as a subject in its own right, but to exploit programming to teach mathematical thinking. A stronger claim would have been to teach generic (i.e. domain-independent) thinking skills. But thinking has to be about something, it does not exist in vacuum. (2007)*
- *The richness of non-numeric topics open to programming has been exploited for developing curriculum sequence in the arts, sciences, and language study. For example, Horacio Reggini[21] developed extensive Logo-based materials in visual arts areas. Paul Goldenberg and I[22] developed a foundational course on language and linguistics that utilizes Logo's highly developed capabilities for language manipulation. (2007)*
- *Because cognitive skills are domain-dependent, one should not expect that the problem-solving competence acquired in one domain will transfer to others. Thus, it is not surprising that Logo programming skills do not directly transfer to problem solving in other domains. Logo programming can be expected to have stronger effects on the development of meta-cognitive skills. These are components of learning that may be domain-independent, and that function as executive processes to monitor the progress and products of cognition. They include skills such as self-monitoring, comprehension, time management, and reflectivity. There is evidence that the use of Logo to teach programming facilitates the transfer of such skills in children. (2007)*

From 1971 to 1974, BBN made "DEC 10 Logo"[23] available to over 100 universities and research centres who had requested it for their own research and teaching. The advent of microcomputers catapulted Logo into becoming one of the most widely used educational languages during the 1970s and 1980s. Logo was employed in mathematics, computer science, and computational courses from elementary through undergraduate levels.

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[20] thus, most probably, the Emerson Elementary School in Newton was the first primary school ever to get access to a computer

[21] Feurzeig is most probably referring to (Reggini, 1986)

[22] see (Goldenberg and Feurzeig, 1987)

[23] then the actual version of Logo

Education should aim to help children succeed in tasks that they have to work at, that take time, and that require a significant investment of thinking. Such learning experiences also teach children how to make a serious commitment to a task or subject area. Throughout its history, the Logo movement has played a significant role in fostering these goals, and it continues to do so, both within schools and outside. Logo may have gone underground in U.S. schools. But the influence of the ideas and philosophy underlying Logo remains powerful and pervasive, in the world and even in my country. (2007)

Figure 2.2 Wallace Feurzeig, photographed in Bratislava in 2007 (photo P. Tomcsányi)

Alan Kay, then a young doctoral student at the University of Utah, College of Engineering, was pondering over the idea of a desktop personal computer in the late 60s when he visited Papert in 1968 and learned about the Logo project. While flying back home from Cambridge he envisioned – and sketched – the Dynabook, *a portable interactive personal computer, as accessible as a book* (see The Dynabook Revisited, 2002), which is considered the prototype for the notebooks of today. He realized that *the desktop computer was just a phase, and what we needed to be doing was working on a* ***computer for children***. He was dreaming about a new portable device, a medium through which children could capture significant truths and communicate important things, *an instrument whose music is ideas.*

This is how the first ideas emerged of a special digital device for children, coupled with a rich software environment, where powerful learning would be fostered. That is, a learning environment where children would solve problems, express themselves, do simple programming and get things to happen – attributes of *learning by making* so typical for the whole **Logo culture**.

When Papert was summarising the "Logo spirit" or Logo culture 20 years later in his excellent introduction to (Logo Philosophy and Implementation, 1999) he wrote:

> *Looking into the future, I certainly see the likelihood of new and more powerful programming systems. Many have been suggested. But one can be sure that an alternative culture of educational programming will not emerge soon, or ever. Such a process needs time, and all indications are that likely contenders for leadership in any such movement have espoused the central principles of the Logo culture. This claim is not based on an arrogant belief that we the inventors of the Logo philosophy are smarter than everyone else. It is based on the belief that the Logo philosophy was not invented at all, but is the expression of the liberation of learning from the artificial constraints of pre-digital knowledge technologies.*

Figure 2.3 Girls working with iPad, S9

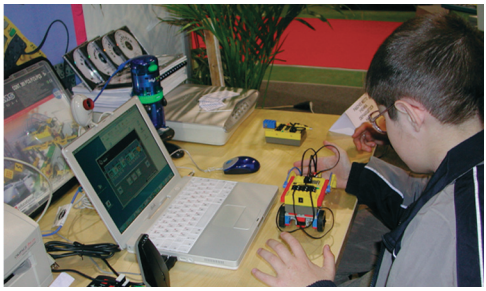
Historical notes from the Russian Federation

*The concept for **learning Informatics and computers in primary school and even at earlier ages** and an experiment with a hundred children started in the mid 1970s in the Soviet Academy of Sciences, Siberian Branch, in Novosibirsk[24]. Simple but powerful programming languages running on mainframe computers were used, including some visual "microworlds" for children.*

*In 1986, a government initiative was launched[25] to develop a **new model of school** for the country (including ICT). The model was based on a constructionist approach, inquiry learning, using ICT and global cooperation. It bore the seal of perspective of academicians who developed it, in line with (a) the Moscow tradition of teaching in specialized math schools, (b) experience of the Bulgarian Research Group on Education[26], and (c) the Epistemology and Learning Research Group at MIT[27]. Particular manifestations of the project activities included the establishment of the Moscow **children's computer club** based on Atari computers, and the publication of the journal **Informatics and Education.***

*One of the core activities of the project was to reconsider the primary school curriculum. A new subject was established **integrating mathematics, language and informatics**, based on a **visual-logical-game** approach and **project-based** learning. It used ideas from mathematical logic and computer science, modern linguistics as "exact natural science", and the discovery approach developed in the Russian mathematical education tradition for gifted children. This subject was piloted in 1989 in the first grade of Moscow School No. 57. It was **not based on using actual computers** but provided a solid 21st century fundamental basis for using them. In later years Logo was added but not really integrated into the subject.*
*In recent years, in the Russian Federation, it became apparent that any **effective process of integrating ICT into (primary) schools** should be based on a holistic transformation embracing such components as **human** (vision, development), **content** (standards and digital learning materials), **technology** (hardware and software, connectivity, services), and **normative** (formal and informal rules for school life). This vision became the basis for the **Concept of Informatization for the Schools of Moscow Region**[28].*

[24] the initiative was conducted by A. Ershov, Y. Pervin and G. Zvenigorodsky
[25] headed by E. Velikhov, A. Semenov and A. Ershov
[26] represented by B. Sendov
[27] headed by S. Papert
[28] developed by a team headed by A. Smirnov and A. Semenov



The New Federal State Educational Standard on Primary Education was developed between 2007 and 2009, with a key requirement of using ICT in all processes. See more in Appendix 1: National policy summaries.

Figure 2.4 The student's desk, S4

Historical notes from the UK, based on (Agalianos et al., 2006)

By the end of the 1980s, following the introduction of microcomputers into schools, Logo became available to a large number of UK mainstream classrooms. At the same time, the publication of Papert's book Mindstorms (1 980) made Logo (and its philosophy of education) known to a worldwide audience and offered an alternative, radical vision for education, which caught the imagination of a large number of educationalists.

The introduction of Logo in UK schools was initially ***not a centrally organized educational reform****: it was a grass-roots innovation that was employed as a way to change existing educational arrangements and orientate them* ***towards child-centred and open-ended exploratory learning****.*

However, the initial delay in producing a full version of Logo for the BBC Microcomputers already bought in large numbers by schools (the gap between 1982 and 1984) had some surprising effects, the legacy of which still exists today. Several individuals and amateurs produced little graphics-drawing packages, usually written in BASIC, which were called "Logo". By 1993, Logo and turtle graphics were effectively regarded as the same thing, and this had also been written into the National Curriculum. From being a computer language of interest to education, Logo in the UK had become equated with a language for turtle graphics.

As a result, DART (one of those simple drawing packages), not Logo, was the formativ e experience for teachers in the UK – the Logo philosophy without the language through which it was expressed. Consequently, the notion of computer language degenerated to "precise sequences of instructions". Thus, from an experimental tool in the classrooms of dedicated enthusiasts, Logo – solely as a language for turtle graphics – became "part of the curriculum". This marked the beginning of a shift away from Papert's original intentions of "educational megachange" (possibly even bypassing the school system), towards ***evolution rather than revolution****.*

> *So Logo became a way of ordering turtles around the screen. Turtle drivers such as DART shaped the attitudes of a generation of primary and secondary teachers, and at the same time, such programs were conjured into existence to express these attitudes and priorities. Drawing pictures with a turtle became a new curricular compartment. Logo became* ***marginalized*** *by its very incorporation – everything had changed but nothing had changed (Noss and Hoyles, 1996 : 163).*

2.2 Learning for the future

Much has changed during the decades between the first efforts to use programming languages like Logo with young students to develop mathematical thinking skills, and the world of today. Digital tools including personal computers, smart phones, and other devices are increasingly prevalent, and in some countries ubiquitous, in homes, classrooms, and society.

During that same era, expectations for what it means to be a literate and participating member of society have also changed. Also, there is broad agreement among business leaders from around the globe that the knowledge and skills needed for success in today's world are not the same as they were not so very long ago. A project asking four hundred hiring executives of major corporations to identify the vital skills that students graduating from secondary schools, technical colleges and universities are lacking, came up with the following:

- Oral and written communications
- Critical thinking and problem solving
- Professionalism and work ethic
- Teamwork and collaboration
- Working in diverse teams
- Applying technology
- Leadership and project management (Trilling and Fadel, 2009)

Another project, led by the International Society for Technology in Education (ISTE) asked thousands of teachers and school leaders to identify the **most important knowledge and skills for today's digital-age students**. This grassroots project resulted in a set of standards that includes elements of several of the types of skills identified by business leaders. These areas include the ability to:

- Demonstrate creativity and innovation
- Communicate and collaborate
- Conduct research and use information
- Think critically, solve problems, and make decisions
- Use technology effectively and productively
- Provide leadership as a global digital citizen (ISTE NETS for Students, 2007)

A third project, called the Assessment and Teaching of 21st Century Skills (ATC21S), started with a group of more than 250 researchers across 60 institutions worldwide who categorized 21st century skills into four broad categories:

- **Ways of thinking**. Creativity, critical thinking, problem-solving, decision-making and learning.
- **Ways of working**. Communication and collaboration.
- **Tools for working**. Information and communications technology (ICT) and information literacy.
- **Skills for living in the world**. Citizenship, life and career, and personal and social responsibility.

While each of these frameworks emerged from different processes and groups of people, the overlap and shared imperative is unmistakeable. Countries, communities,

and classrooms around the globe are looking for effective ways to develop the knowledge and skills to thrive in an increasingly complex and digital world.

As the needs of society and the skills required to thrive in today's world have shifted over time, the call to use technology to support young learners in becoming creators, mathematical and computational thinkers, collaborators, inventors, and problem solvers and communicators has not changed. Digital tools are becoming easier to use, more powerful, and less expensive with time. In today's world, technology affords students access to experiences otherwise inaccessible, allows them to access current information about the world around them, and provides tools with which to think and experiment.

Figure 2.5 Deerfield Community School KinderKids, see http://mariaknee.com

In Maria Knee's Kindergarten classroom of children age 5-6 at Deerfield Community School in New Hampshire, USA, students create videos and talk using voice over the Internet to connect with young learners around the globe. They document and discuss weather, their community, local traditions and other topics of interest. Students in New Hampshire describe, step by step, the process for gathering maple sugar to five-year-olds in Australia who in turn, ask clarifying questions. Shaun, Max and Owen use a tool called Sock Puppet to create a video demonstrating how to count by 10s on the iPad. The class has a blog where they share their learning and projects and receive comments and suggestions from readers. The children are learning to use digital tools to collaborate with peers in their classroom, and peers around the world. They create multimedia products to demonstrate their learning and illustrate ideas, hone their verbal and written communication skills, and incorporate information otherwise outside their daily experience using the Internet. In these ways they use a range of standard technological tools to foster creativity, curiosity, and knowledge creation.

In addition to technology providing access to new learning and experiences, living in the digital age also requires new skills so that young learners grow up to use the power and potential of digital tools to solve grand challenges, create new products, and invent solutions not even in our current imagination. At an early age, students can begin to develop the thought processes and aptitudes that will grow over time into the set of skills needed not only to use technology

but to create future technologies. Known as **computational thinking**, these skills include:

- Logically organizing and analyzing data;
- Representing data through abstractions, such as models and simulations;
- Automating solutions through a series of ordered steps;
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources;
- Generalizing and transferring this problem-solving process to a wide variety of problems;
- Formulating problems in a way that enables using a computer and other tools to help solve them.

Figure 2.6 Technology assisting young readers learning to decode

In addition to these core skills, certain attitudes are important for a learner developing computational thinking skills:

- Confidence in dealing with complexity;
- Persistence in working with difficult problems;
- Tolerance for ambiguity;
- The ability to deal with open-ended problems;
- The ability to communicate and work with others to achieve a common goal or solution (Barr et al., 2011).

Figure 2.7 Boys taking turns at making their Bee-Bot pass through the town

These **thinking skills**, started at an early age, are the building blocks for the digital inventors, creators, problem solvers and game changers of the future.

There is little argument that the world is changing and the knowledge and skills young learners develop must change as well. Countries around the globe are racing to reform education systems and curricula to address the changing realities of a digital world (see *Chapter 5 National policies, strategies and curricular documents)*. While there is widespread consensus about knowledge and skills of a digital age learner, the context of economic, religious, and cultural beliefs has a profound impact on how these skills are taught.

2.3 Respecting and sharing

One of the frequently discussed issues is whether ICT in education over-promotes **global aspects** and tends to neglect **local and regional cultural and religious values**. Do education systems in different countries produce *global citizens* and to what extent should they do that?

There is no doubt that with ever-evolving digital technology and communication, our world is gradually turning into a *global village*, with similar goals and aspirations everywhere. Whether education systems around the world acknowledge the importance of digital technologies or not, **students will anyway use them to learn, play, communicate, and interact**. Our students are able to access technology and particularly the Internet a variety of forms, even in many underprivileged places in the world, simply because it interests them; they are therefore able to learn themselves how to use it (a good example of this is the *The Hole in the Wall* project conducted by Dr. Sugata Mitra, India, mentioned later in this section).

It would therefore seem that in a globalised economy, with evolving technologies and raised interest of children in technology coupled with 21st century challenges, *global citizens* are a much needed commodity and the education systems around the world need to cater for that. However, should integration of ICT in education because of that follow a simple-minded approach ignoring cultural norms and religions?

In fact, countries and governments all over the world, including those that are politically among the most conservative, are catching on to the necessity of education reform and the possible role technology should take within the educational system. We may take Saudi Arabia as an example. A multibillion Saudi Riyal education reform programme *Tatweer* has been launched (see more on this initiative later in this section) with digital technology being key to the programme.

Similarly, countries with challenging economic situations are seeking innovative and creative means to reform and integrate new technologies into education. In fact a trend of multi-stakeholder partnership in education has emerged during the past decade, a trend the World Economic Forum[29] has been promoting since 2003, starting with the launch of the Jordan Education Initiative, JEI[30].

Figure 2.8 Reading project, C2

[29] see *www.weforum.org*
[30] see *www.jei.org.jo*

Whilst there is general agreement on the need for technology, is there really a debate that using technology may have a negative impact on religious and cultural norms? What is such a debate about? In ***"I" "C" "T"***, one will seldom find a debate about the ***"T"***, the majority believe that ***Technology*** is an appropriate tool for teaching and learning. As for the ***"I"***, especially since the dawn of the 21st century, people believe in is the era of ***information***, and the necessity for information as the basic stuff of knowledge economies. However there is some scepticism with respect to the sorts of information that a student can access that might be culturally, religiously or morally not acceptable; this is a general concern all over the world and not necessarily limited to certain countries or certain regions. A natural progression of the debate goes to the ***"C"***, when students are able to ***communicate***, surpassing physical and time boundaries. Similar debates can be found in both politically conservative, or less economically challenged nations. In such situations, one may find a common fear associated with what kind of information students may access through the Internet, and what kind of unacceptable ideas may develop in their minds (especially at a young age) if they start communicating with other students from different countries, races or religions.

Taking a closer look at the Arab and Islamic world, over the past decade, most governments have and still are investing in introducing technology in schools, in addition to the fact that many children are using the Internet at home. These countries, however, are taking measures to deal with the concern regarding access to the Internet and Internet-based communications. For example countries like Saudi Arabia or the United Arab Emirates restrict access through the Internet providers, whereas countries like Jordan, Lebanon, Qatar and others provide open access to the Internet with the option for schools and homes to have restricted access to the Internet in what they call *Safe Internet*.

There is a shared belief that technology and Internet are an necessity to create the *global citizen* who can contribute to the knowledge economy. One can find this view in economically affluent and strict societies like Saudi Arabia, as well as economically challenged countries all over the Middle East and Africa. It is also interesting to observe that all of these societies believe in the necessity to **introduce ICT and Internet at the primary school level**, as it is believed that we need to prepare students at a young age to be able to deal with technology. Following are a few examples from around the world.

Saudi Arabia

In 2006, King Abdullah bin AbdulAziz launched **Tatweer**, a comprehensive multibillion Saudi Riyal initiative to reform public education in Saudi Arabia[31]. Within this initiative, there are several projects focused on introducing electronic content, training teachers to use technology, and providing an national education portal. One example is *the project to enrich educational content online*. The project description shows the Saudi government position towards technology: *Internet has become a strategic choice for learning for all people, especially among general education students who grew up with the technology*. The objectives of the project are:

1. Enrich learning in the areas of online education for students.
2. Stimulate outstanding students, teachers and specialists to produce digital content that will help provide a rich learning environment for all.
3. Assist in the discovery of the energies of teachers and outstanding practices.
4. Motivate the participants to increase their participation and contributions to an outstanding online community.

[31] see *www.tatweer.edu.sa*

Jordan

In 2003, Jordan and the World Economic Forum launched the **Jordan Education Initiative**[32], whereby partners from global and local private sectors teamed up with international organizations and the government of Jordan to bring about an effective model of integration of ICT in education, with a focus on producing digital content which complements the reformed curriculum. By the end of the four year programme, in 2007, Jordan felt there was so much need for this collaboration and belief in the cause of integrating technology in education, that Her Majesty Queen Rania Al Abdullah Queen of Jordan, decided to re-launch the JEI with a Jordanian mandate as a not for profit organization, under the patronage of Her Majesty. Now the JEI is considered the arm of innovation to government and the bridge that brings about effective collaboration between the private sector and government. But most importantly, JEI currently works with 200 K-12 public schools, introducing the latest advancements of technology in education into these schools, and making them role models for other schools. Additionally, the JEI also serves in an advisory capacity to both ministers of education and ICT on all issues related to ICT in education.

India

In 1999, Sugata Mitra and his colleagues used a hole in a wall bordering an urban slum in New Delhi, installed an Internet-connected PC, and left it there (with a hidden camera filming the area). What they recorded were kids from the slum playing around with the computer and in the process learning how to use it and how to go online, and then teaching each other.

This experiment showed that groups of Indian children, given shared digital resources can learn to use computers and the Internet to learn almost anything on their own that they have an interest in. They do not seem to require adult supervision.

Further work showed that groups of children with access to computers and related technology are capable of successfully answering examinations without traditional schooling.

Note however that there have been critical reactions as well, see e.g. (Arora, 2010), to these general conclusions.

To conclude, it is believed that ICT and Internet are the way forward in education to raise *global citizens* who will participate in building the knowledge society. The examples portrayed in this section demonstrate that even countries with strict religious and cultural norms, as well as poor countries, agree on the importance of ICT and Internet in education. However they are taking some or all of the following measures to make this use consistent with their national religious beliefs:

- Provide **Safe Internet** on the national level restricted by the Internet service providers like in Saudi Arabia and the UAE. This restriction is at the national level for all users.

[32] see *www.jei.org.jo*

- Provide **Safe Internet** as a service allowing the user to make the decision, like Jordan.
- Provide intranet access to safe Internet at the school level.
- Launch general awareness initiatives providing knowledge at the community level on modes and means of using safe Internet.

The common belief in all countries is that technology and Internet are an integral part of education. However, we know that students will also find means to overcome the strictest filters to the Internet. Therefore it is crucial **to create awareness, knowledge and focus on promoting beneficial use of the Internet**.

2.4 ICT in present-day schools: different models of implementation

As described above, countries use a variety of strategies to protect the safety of children while they access the Internet. In spite of that, nearly all countries – no matter which religion or value system they adhere to – agree that school (including its primary level) ought to develop students' digital skills, digital literacy, and appropriate digital behaviour as part of developing 21st century skills.

To reach this goal, there are different strategies and models of implementation, with varied values and priorities (see more in Chapter 5 on national strategies). In a broad range of approaches we can distinguish three main models (which are adopted in various combinations):

(a) ICT integrated across the curriculum

In this model, ICT is incorporated in subjects to enhance particular learning outcomes, although often augmenting cross-curricular relations between them as well. As often quoted in the literature[33] ICT within subjects can serve various mediating and motivating roles. Besides that, as shown e.g. by ITL Research (2011), ICT also helps create opportunities for developing 21st century skills. It is also clear that the success and benefits of this model depend critically on the level of digital literacy of teachers – not only on their own ICT skills, but on their experience and innovativeness in new digital pedagogies, and their personal capacity and interest to create new teaching and learning environments, and cooperate with other teachers:

> *Asking whether technology can improve education is like asking whether experiments can improve science education. Everything depends on what kind of technology is introduced, how it is used, its design and how teachers are supported to use it.*
>
> *R. Noss, Director of Technology Enhanced Learning Research Programme (in "UK Science & Technology", issue 3)*

(b) ICT as a distinct curriculum subject

As a subject, ICT is usually focused on developing basic computer literacy, productive use of common office applications, presentation and multimedia tools, databases, information systems and web search, drawing environments, etc. The risk in this approach is that teachers of other subjects may be insulated from the critical need to integrate ICT to their own teaching processes.

And indeed, the quality and effectiveness of routine ICT classes are increasingly being discussed – and sometimes disputed:

> *There is a significant and growing base of evidence, not least from Ofsted inspections, that demonstrates that there are persistent problems with the quality and effectiveness of ICT education in schools. Evidence indicates that recent curriculum and qualifications reforms have not led to significant improvements in the teaching of ICT, and the number of students progressing to further study in ICT-related subjects is in decline. Furthermore, the ICT curriculum in its current form is viewed as dull and demotivating for pupils. Its teaching may not equip*

[33] see chapter 3 for a research literature review

pupils adequately for further study and work, may leave them disenchanted or give rise to negative perceptions that turn them off the subject completely.

Michael Gove, Secretary of State, United Kingdom Department for Education, 2012

Recently published in the UK, the Royal Society Report called *Shut down or restart? The way forward for computing in UK schools (2012)* proposes *a radical overhaul of ICT in schools including rebranding and providing clarity on the different aspects of Computing currently lumped together under this heading…* and *concludes that …current delivery of Computing education in many UK schools is highly unsatisfactory*. One of its recommendations for new curriculum is:

- *Establish schemes of work for age 5 – 14 across the range of Computing aspects, e.g. digital literacy, Information Technology, and Computer Science.*

Figure 2.9 Modern visual and interactive programming and programs for primary stage children have surprisingly miscellaneous forms nowadays, the example shown here is Kodu – a programming language created specially for developing games, for children and by children[34]

(c) Informatics (Computer Science) as a distinct curriculum subject

In this relatively new model there exists a separate, mandatory subject called Informatics[35] or Computer Science or Computing or ICT, however with broader goals than in model (b), namely developing understanding of elementary Informatics concepts and skills, such as the following:

- digital literacy (basic knowledge, skills and concepts of Informatics and computers; computer literacy, working with applications; safety in a digital world);
- programming or computational thinking (in the sense and scope described in section 2.2);
- problem solving (logical reasoning, justification, argumentation; puzzles, riddles and problems; strategies for problem solving);
- data handling (organizing and analyzing data, patterns and structures) – for more information see Kalaš and Tomcsányiová, 2009.

[34] see *research.microsoft.com/en-us/projects/kodu/*

[35] the name Informatics is often used as equivalent to Computer Science, especially when indicating a school subject

The third model is still rare in primary education, however it exists in a few countries and is being seriously discussed in many others, see for example a collection of papers on this topic in (Kalaš and Mittermeir, 2011), and there is a clearly growing attention to this issue in conferences and research projects, discussions, special interest groups and events of leading institutions and technology companies like ISTE, Microsoft, Lego, Cisco and others.

An inspiring informatics-based approach is being implemented in the Russian Federation. Its authors believe that:

> *Informatics is an important part of primary school education for the 21st century. By Informatics we understand here a field of science that uses mathematically formulated notions and mathematical methods of reasoning for discrete finite objects and processes applicable to formal human reasoning as well as to electronic computing, control and software engineering… The subject can be naturally integrated with the course of mathematics to build a New New Math not with more abstract definitions (as it was in New Math), but with more concrete visual understanding by example and learning by doing. The most important feature of providing material for students in our approach is permanent high level of novelty in problems to be solved. This can be called Pedagogy of New.*
>
> *E. Bulin-Sokolova, A. Semenov and V. Vardanyan (2011)*

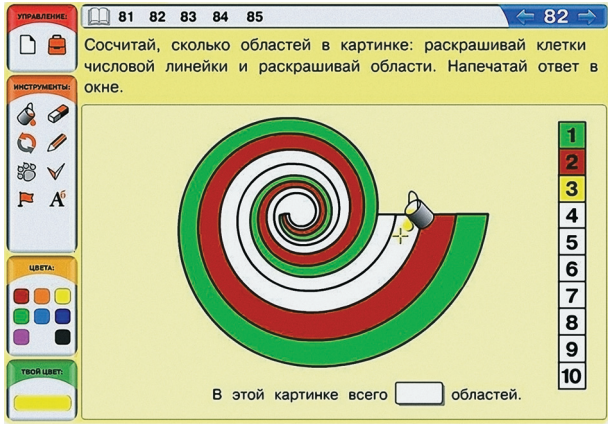


Figure 2.10 This assignment asks children to conclude how many regions there are in the figure – by filling them in different colours. Adopted from (Semenov and Rudchenko, 2010)

A new primary subject called *Mathematics and Informatics* is being piloted at 180 Moscow schools. It creates opportunities for *independent learning, research and practical activities understandable and attractive for students* (Rudchenko, 2011), see Figure 2.10.

It is more than obvious that the area of ICT or Informatics in primary education is dynamically developing and bringing about many interesting questions, opportunities, and demands for systematic educational research. In the following chapter we will focus on what the existing research literature says about this vigorous topic.

3 What does the research literature say about ICT in primary education

The previous chapter has highlighted the cultural-historical and educational roots of using ICT to enhance teaching and learning in primary schools. In the last two decades, governments and educators all around the world have recognised these opportunities. This chapter draws upon existing research and evaluation publications on how ICT has been used successfully or unsuccessfully in schools to enhance students' learning outcomes, and identifies the conditions that support or hinder these ICT-mediated teaching and learning practices. For ICT to enhance teaching and learning, it needs to be supported by appropriate education and school policies and by effective professional development for teachers. Moreover, despite an increasing recognition of 21st century skills and competencies, there are certainly cases where a lack of ICT infrastructure, hardware and software in schools can deny students the opportunities to properly develop these competencies.

This chapter is organised into four sections:

1. Opportunities provided by ICT for teaching and learning in primary schools in literacy, numeracy, science, and 21st century competencies;
2. The limitations of ICT and associated concerns in primary schools;
3. The roles of teachers in ICT-enhanced teaching and learning in primary schools; and
4. Evidence for the necessary and sufficient conditions to support ICT-enhanced teaching and learning practices in primary schools.

These sections should serve as conceptual anchors for readers as they make their way through the subsequent chapters in this book, and later outputs of the project.

Figure 3.1 Video staging, S4

Figure 3.2 Engaged in common work, S5

3.1 Opportunities Provided by ICT for Teaching and Learning in Primary Schools

As ICT weaves itself into the activities of primary schools, it brings about changes in learning and teaching activities, in curriculum, and in interpersonal relationships in the learning environment, and it is reciprocally affected by the very changes it causes. Therefore, the integration of ICT in schools must focus on the whole configuration of events, activities, contents, and interpersonal processes taking place in the context that ICT is used. Depending on the expected learning outcomes and activities, ICT plays different roles in the learning environment. In this section, we examine the opportunities ICT provides for teaching and learning in primary schools with respect to enhancing learning outcomes in: (1) literacy, (2) numeracy, (3) science, and (4) 21st century skills.

ICT may serve various roles in schools for the purpose of enhancing students' learning. Based on how an ICT tool is used in the classroom, Lim and Tay (2003) classified ICT tools into four types:

1. **Information tools**. These are applications that provide information in various formats (e.g., text, sound, graphics or video). Examples include multimedia encyclopedias or resources available in the World-Wide Web (www).
2. **Situating tools**. These are systems that situate students in an environment where they may "experience" a context and happenings. Such systems include simulations, games and virtual reality.
3. **Construction tools**. These are usually tools that can be used for manipulating information, organizing one's ideas or representing one's interpretations. For instance, mind mapping or social networking applications that allow students to organize their ideas or reflections, and communicate these ideas and share with others.
4. **Communication tools**. These are applications that facilitate communication between teacher and students or among students beyond the physical barrier (of space, time or both) of the classroom. The important examples are e-mail, e-conferencing and e-discussion boards.

In addition to these four types of roles, ICT may also serve other roles such as tutorial and diagnostic tools; and in real classroom practices, ICT often serves more than one mediating role simultaneously.

Literacy

Literacy instruction traditionally emphasizes the acquisition of specific skills and information, but downplays the importance of analytic use of language. Recent developments in educational psychology suggest that literacy is best taught within a context that stimulates problem solving and analysis along with reading, writing, and ICT literacy competencies. ICT can offer such learning opportunities (Alfassi, 2000). While learning with ICT, students are likely to become thoughtful, literate users of language. Here we explore the different roles ICT may play for enhancing learning outcomes related to literacy.

ICT information tools

In Alfassi's (2000) study of language classrooms, the teachers involved developed different assignment tasks that engaged their students in meaningful inquiries while

using ICT information tools. The students applied research skills as they used the Internet and CD-ROMs as information tools to search for information and use critical judgment to determine if the information is accurate, relevant, and useful. The students also prepared electronic presentations in which texts were written, read and animated with accompanied music or sound effects. Through these electronic presentations, they improved literacy and communication skills because such presentations required them to interact with each other while using various forms of speech, symbols and logical analysis. The study found that after using ICT-enabled information tools, the students had significantly improved on their reading comprehension and writing.

ICT tutorial tools

Many studies have examined the use of ICT tutorial tools in language classrooms. Lirola and Cuevas (2008) found that by using a combination of computer programs students improved their writing. Edwards, Monaghan and Knight (2000) argue that bilingual stories in interactive software provide a basis for activities and discussion and can increase students' language awareness and foster their positive attitudes towards language learning. In Brooks et al.'s (2006) study, a computer program was designed to enhance students' reading and spelling through phonological awareness. Software is particularly useful for students having special needs. Research has shown that students with reading problems learn to decode words more effectively when given speech feedback. For example, Wise, Ring, and Olson (2000) found that computerized phonological training supports accurate decoding in reading. Software can also be used to alleviate the problem of keeping-on-track and accidental skipping, by for instance highlighting words or lines in response to simple keystrokes (Fasting and Lyster, 2005). ICT tutorial tools also allow students to navigate to different areas of a package depending on their personal interests or needs (Watts and Lloyd, 2004).

ICT situating tools

The virtual world "Barnsborough" described in Merchant's (2010) study was demonstrated to be a good multimedia device, constructive to literacy learning both behaviorally and psychologically. It was specifically designed for literacy learning and problem-solving. Merchant found in the study that most participating students expressed a sense of enjoyment, motivation, and engagement when talking about their experience of visiting the virtual world; teachers also tended to agree that Barnsborough was a useful situating tool for real-world literacy learning and teaching. Ariew and Ercetin (2004) found that students had positive feelings toward hypermedia reading. As for writing, Watts and Lloyd (2004) focused on the impact of a multimedia package called "Espresso". The interactive nature of the materials encouraged collaborative work; the real and up-to-date nature of the materials provided clear motivation for students and the space for creativity. Learning with Espresso allowed students to be active learners as materials came with audio-visual effects, and these could be selected, rewound and fast-forwarded, thus allowing students to control their own learning.

ICT construction tools

Digital storytelling provides a good example of construction tools. It refers to the art of telling stories with a variety of digital multimedia, such as images, audio, and video. Digital story telling can be an effective means for literacy instruction in the primary school. Halsey (2007), a New Zealand primary school teacher, reports how she encouraged her students to use podcasts and online publishing as new ways to learn literacy. She observed her students' excitement for learning in the new ways as

Figure 3.3 Gracen Flores, Grade 4 is preparing a book talk movie using iMovie and claymation, S9

they honed their skills in reading, speaking, listening and writing; publishing students' works online also provided students with an audience and therefore an authentic purpose for learning. Halsey believes that learning with new technologies supports a constructivist approach for learning and is most effective when students are allowed autonomy over their own learning process. In a recent project on creating 3D digital multimodal curriculum for upper primary schools in Australia, Chandler, O'Brien and Unsworth (2010) described how students used 3D digital movie-making software to tell stories and develop their literacy and thinking, as well as other skills such as self-management and planning.

ICT communication tools

Studies have found that communication tools such as e-mail may contribute to students' acquisition and performance in writing. For example, Shang (2007) found that students who are regular users of e-mail showed improvement in their writing performance and independent thinking. Biesenbach-Lucas, Meloni and Weasenforth (2000) found that e-mail is effective for students to practise cohesive devices such as demonstrative pronouns, sentence connectors, and summative expressions. Communication tools such as chat rooms may also be used together with other multimedia packages such as e-books. For instance, Lai and Zhao (2006) found that students in a text-based online chat room noticed more language usage errors than in face-to-face conversations. Hartley (2007) states that ICT-mediated writing can release students from dealing with many problems associated with writing by hand – like letter formation and alignment – and hence facilitate editing, rewriting and spelling. Freedom from these chores allows them more time for thinking and reflecting about the content of writing.

Blogging (or weblogging) is a recent and growing phenomenon that has been deployed in primary education for the purpose of literacy instruction. In Halsey's (2007) study in a New Zealand primary school, a class website was built jointly by the teacher and the children allowed them to publish and share their works with parents, children from other schools, and the general public. In his paper advocating use of blogs to promote literacy in the classroom, Huffaker (2005) argues that the characteristics of having a personal space and interconnections among an online community promotes individual expressions and collaborative interactions in the form of storytelling and dialogue; the

paper reports use of blogging for literacy instruction in different age groups in primary schools, for writing and allowing communication and sharing among teachers and students.

Mathematics (Numeracy)

ICT has changed fundamentally the ways that people use mathematics, and so also it may change the content of mathematics courses, and the methods by which mathematics is taught.

ICT construction tools

ICT can facilitate teaching and learning of mathematics through inquiry-based learning like "WebQuest" activities, in which students work with information they find from the Internet. Halat and Peker (2011) compared the influence of instruction using WebQuest activities and spreadsheet activities. Spreadsheets offer the potential to encourage students to explore and express mathematical ideas when solving problems; as Sharp (2003) sums up, spreadsheets are functional for setting up calculations, changing cell values and looking at the effect on the results immediately. Echoing with the results of some earlier studies, Halat and Peker (2011) found in their

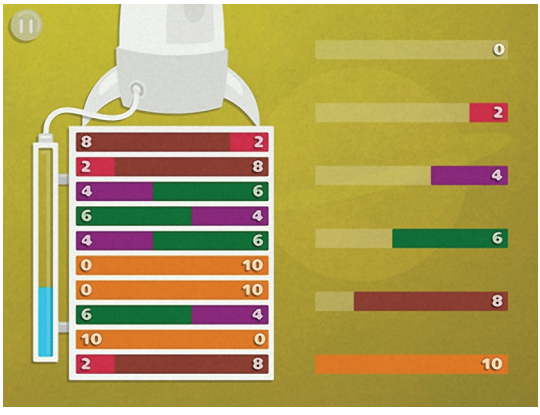


Figure 3.4 An application for learning the pairs of numbers that add up to 10 (United Kingdom). As a coloured rod falls into the fuel tank, the learner has to select the corresponding rod that makes up 10. They can see if it is right, or too short, or too long. Once they are all correct the rocket has enough fuel to take off!

experiment that in WebQuest, students are able to do more mathematical activities and explorations in a game or in a story than just practicing mathematical rules. Given that the WebQuest-based applications for mathematics instruction also had great positive effect on the motivation of the pre-service elementary school teachers, they believed that developing WebQuest-based activities would be beneficial for both teaching and learning mathematics.

Tangram puzzles are a common topic for primary geometry. Lin et al. (2011) conducted a study to see if a collaborative and manipulative digital Tangram puzzle could facilitate learning geometry in a computer-supported collaborative learning environment based on Tablet PCs. They wanted to see whether children can develop mathematical concepts through playing with Tangram puzzles collaboratively, and solving problems together through discussion. A number of advantages of the software were identified: (1) it enhanced the students' perception of shape rotation and their spatial ability; (2) it improved students' competence in spatial reasoning and sensing; (3) it increased

face-to-face discussions as well as online communications among students; and (4) it boosted students' critical thinking, confidence and willingness to learn. In addition, teachers also found it easy to summarize and explain the geometrical concepts involved using the virtual Tangram puzzle.

ICT information tools, tutorial tools and construction tools

Robots as instructional assistants or learning companions may enhance students' motivation and learning performance (Barker and Ansorge, 2007); robots may also enable teachers to provide digital learning content which facilitates students to interact with real learning materials (Jermann, Soller, and Mühlenbrock, 2001). Wei, Hung, Lee and Chen (2011) demonstrated a design called Joyful Classroom Learning System (JCLS). The system consists of a robot learning companion (RLC), sensing input device, mobile computation unit, mobile display device, wireless local network and operating software. The authors found that (1) most learners agreed that using the JCLS with RLC really enhanced their learning motivations; (2) many learners commented that learning with RLC was more interesting than learning in a traditional classroom; and (3) some learners expressed that the opportunity of making several tries to figure out the correct answer was very useful for them to figure out the reasons for the mistakes they had made. The authors argue that the JCLS can provide learners with more opportunities for hands-on exercises, and deepening their engagement with the learning contents. Learning with the system also allowed learners more thinking time for knowledge construction. They found that using robots can increase students' motivations/interests and result in a more enjoyable learning process. At the same time, the JCLS can also support teachers to monitor in detail what every student is doing, and thus to adjust in-class instructional strategies, and provide after-class support.

Science

Nowadays, science teachers are encouraged to design learning activities that can give students opportunities to use ICT to search and analyze information from multimedia resources; synthesize and communicate results collaboratively with peers and online communities. Social network sites, online games, video-sharing sites, and gadgets such as iPods and mobile phones have become an indispensible element of youth culture today while such technologies barely existed a decade ago (Ito, Horst, Bittanti, Boyd, Herr-Stephenson, Lange, et al., 2008: 1). Some research (e.g., Luu and Freeman, 2011) has found that scientific literacy of primary school students is correlated with ICT experience. Students with prior experience with ICT, who browse the Internet more frequently, and who are confident with basic ICT tasks were observed to attain higher scientific literacy scores. This suggests that using ICT appropriately to teach and learn science can be beneficial to the acquisition of scientific knowledge and the practical use of it.

ICT situating tools

ICT can facilitate the teaching and learning of science in the form of multimedia virtual worlds. For instance, Campbell et al. (2010) discuss an example for learning about life and earth science: "Opensimulator 3D Application Server". This is an open source, modular, extendable platform, which can be used to create simulated 3-dimensional spaces for building plant populations with customizable terrain, weather, and physics. In this environment, students were able to conveniently explore the interaction between particular traits in

organisms, the genes that control those traits, and the effects of changes in the environment, including changes caused by human activities. They could also test hypotheses with virtual experiments and see the results without experimental errors within a short time – this is difficult, if not impossible, in traditional science classrooms.

Educational games provide another tool for the teaching and learning of science. Some researchers believe that game-based learning might be the best way to promote students' learning motivation (e.g., Huang, 2011). Some studies indicate that a game-based learning approach can provide ways to stimulate children's abstract thinking during the process of cognitive development, and further foster their higher order thinking ability (e.g., Carbonaro, Szafron, Cutumisu and Schaeffer, 2010). In Yien, Hung, Hwang and Lin's (2011) study, a game-based learning approach to nutrition was tested with primary students. The results showed that the students strongly confirmed the positive influence of computer games on their nutrition knowledge; they also expressed a hope that game-based learning could be applied to other subjects. Lim, Nonis and Hedberg (2006) explored the use of a 3D multiuser virtual environment, known as Quest Atlantis (QA) in a series of primary science lesson in a Singapore school. This study provided useful lessons regarding the incorporation of QA into the primary science curriculum, such as the development of students' language and computer skills, issues of time management, and support from school and parents.

21st century skills

The use of computers and the Internet no longer needs to rely on devices that are fixed in one place; mobile technologies allow interaction via text messaging, and access to the Internet wherever one wants. Today, mobile phones, video cameras and tablet computers are becoming commonplace. With the help of the Internet and technologies for communication, visualization, and simulation, students can be offered a more authentic learning experience. They are able to gain a deeper sense of a discipline as a "culture" shaped by specific ways of seeing and interpreting the world (Chang, Lee, Wang and Chen, 2010). Hartley (2007) explains the use of digital cameras, video projectors, electronic whiteboards, virtual environments, mobile technologies and various types of control switches in teaching and learning. Miller and Robertson (2010) found that using computer games led to significant gains in general self-esteem and high speed of computation for primary school children. These studies show how new technology can and will infiltrate the home and the educational system. Children are even much more relaxed than adults in using these new technologies. Therefore, ICT is likely to be advantageous for the acquisition of 21st century, skills which include ways of thinking, ways of working, tools for working and skills for living in the world (see section 2.2).

ICT construction tools

Yang's (2009) study provides an example of the benefits of using ICT in an oral history course. Yang examined primary school students' affective attitudes and cognitive perceptions in order to understand the challenges and opportunities that students faced in the project. The findings indicated the benefits that learners perceived around learning the importance of teamwork, knowing how to design a homepage, having a unique experience, learning more about history, learning interviewing techniques, and learning how to undertake a research project. The project provided an opportunity for students to sharpen their skills in problem solving and enhance their historical thinking. The most obvious outcome of this project was the students' sense of accomplishment and pride along with an increase in self-growth (e.g. confidence, self-esteem,

Figure 3.5 Digital art pieces by students from S5

responsibility), and a greater empathy for elderly people. The students reported how they learned to see that historical issues can be viewed from a variety of standpoints, and how the standard history that is taught reflects the views of the dominant culture of the time.

ICT situating tools and communication tools

Lim (2008)'s study in a Singaporean primary school provides a case of situating traditional curricular subjects in the context of global citizenship, utilizing a computer game environment called "Atlantis". Set against the story of the city of Atlantis facing ecological, social and cultural decay due to the blind pursuit of its rulers for prosperity and modernisation, each student involved in the study became the central character who was confronted with the mission of saving Atlantis. The case study provides an account of how two classes of primary Grade 5 students engaged in the learning of English, Mathematics and Science by role-playing and solving problems with fellow questers. The results indicate that this approach had positive effects in enhancing students' learning engagement, academic motivation and social commitment.

Figure 3.6 Deeply involved with drawing, S1

3.2 Limitations of ICT and Associated Concerns in Primary Schools

Whilst research has demonstrated the potential of ICT in enhancing teaching and learning, researchers have also identified limitations for its application. School leaders, teachers and parents need to put into consideration these limitations, while encouraging students to learn with ICT.

Limitations of computer programs

While many computer programs may be beneficial to literacy learning, some of them may not be as good as they claim to be. School leader and teachers need to be selective about the programs they choose to use. Moreover, computer technology cannot always substitute teachers' support (Fasting and Lyster, 2005). As for the transformative roles computer games might play in teaching and learning, Merchant (2010) urges us to pay attention to the broader social contexts in which computer games operate. Another important point is that the time commitment in using one software program does not necessarily lead to increased academic performance whether the programme is initially beneficial or not (Campuzano et al., 2009). Therefore, practitioners should be clear about the possible benefits and side effects of each program before adopting it into the school.

Limitations of the Internet

While the Internet is often used for literacy learning, there is right and wrong information on the Internet. While blogs may help students' literacy learning, it may not be the best tool for aspects such as grammatical control while writing (Bloch, 2007). As for reading, allowing students to search for additional lexical and contextual information related to the content may not significantly increase their reading comprehension (Sakar and Ercetin, 2005). Students may overlook the most important information when there is a lot of other distracting information on the computer screen (Lowe et al., 2010). Students' lack of existing knowledge and skills about computers and the Internet, or lack of access to computers and the Internet outside school, may create barriers for some children to use ICT for learning. Thus a balance between traditional teaching and learning with ICT is desirable. Practitioners need to ensure that they supervise students during most in-class activities using the Internet, and they must give sufficient instruction about how to use the Internet for the purposes of learning.

Limitations of multimedia

Multimedia are not necessarily beneficial if they are not properly used or designed. For example, too many attractive "options" on a multimedia text can divert children's attention from its content. Practitioners need to cultivate the **media literacy of students**, so that they can interpret and better use multimedia for learning objectives.

Limitations of ICT caused by time and psychological factors

Psychological factors, such as enthusiasm, can also lead to negative results with the use of ICT in literacy learning. As Merchant (2010) found, students may be unwilling to transfer what they acquire in the virtual world into the real world, and conventional literacy. On the other hand, Chang et al. (2010) noted that sometimes students

might prefer interacting with physically real teaching materials rather than virtual materials. Practitioners need to pay close attention to students' responses to the use of ICT in teaching, and to try switching to traditional teaching if deteriorating learning performance occurs.

Concerns about cyber bullying and cyber-wellness

Safety issues associated with using mobile phones and the Internet have long been the concern of schools parents, such as game addiction, invasion of privacy, bad language use, and danger of online socialisation. "Cyber bullying" as a new form of bullying using new technologies including e-mail, text, chat rooms, mobile phones, cameras and websites has emerged and is a growing problem for children in school (Campbell, 2005). "Cyber-wellness" is a more recently used term which encompasses not only concerns around safety and security online, but also considers young people's psychological and emotional well being (Cyberspace Research Unit, 2006). Schools in many countries have started efforts to promote students' cyber-wellness. For example, the Ministry of Education (MOE) of Singapore has launched various prevention and intervention programs including training teachers, training student ambassadors, and involving parents (MOE, 2011).

While exploring the increasing use of ICT for teaching and learning in the primary setting, the various limitations and associated concerns must be fully addressed by school leaders, teachers and parents to ensure that the greatest advantages of ICT are realized for learning purposes.

Figure 3.7 Connecting everywhere and always, in all possible ways, S3

3.3 The Roles of Teachers in ICT-enhanced Teaching and Learning in Primary Schools

It is clear that introducing a new technology into any learning situation requires a great deal of thought and planning, and a good deal of developmental testing. This process requires multidisciplinary approaches involving teachers, researchers, technologists, developers and students (Hartley, 2007). Teachers play a pivotal role in creating ICT-enhanced learning environments (Lim, 2007). The teacher's tasks include evaluating ICT tools, assessing ICT competencies of students, setting clear expectations, negotiating objectives with students, preparing student for lessons by adopting various scaffolding strategies, and so on (Lim, 2007). In this section we will outline some key roles teachers are expected to play in supporting ICT-enhanced learning.

Teachers must be learners who keep on developing and enhancing their own ICT capacity, in order to guide their students.

Teaching with ICT in primary education requires teachers to act as if they were learners themselves in the computer-enhanced environment (Hardy and Kirkwood, 1994). The Internet is one major aspect of ICT, but the Internet is fraught with misleading and inappropriate information that may harm young primary students. According to Anastasiades and Vitalaki (2011), teachers who are competent and professional in ICT tend to have high sensitivity and be effective in providing pedagogical guidance, promoting Internet safety, teaching students moral behaviours when navigating the Internet for educational, recreational, and interpersonal purposes. In addition, if teachers are concerned about management of websites and possible risks on the Internet, they will be better skilled in engaging students in meaningful online interaction and be more comfortable to use the Internet as a teaching tool. Therefore, teachers play the role of considering all the information available about the dangers related to Internet use, and what is effective training to protect students, and thus guide their students on the issue of Internet safety.

Provide scaffolding activities for students and intervene into their learning.

As primary students are limited in their capacity for self-directed learning, the value of ICT is to a large extent dependent on teachers' strategies. Hudson's (1997) study, conducted in a relatively early stage of ICT implementation, found that teachers are important for fostering peer interaction among students in multimedia-based activities. Teachers play the cyclical role of observation, reflection, recording, discussion and feedback. Teachers not only monitor the interaction ingroup learning, but also use direct intervention (e.g., asking questions to stimulate discussion) to facilitate students' thinking, understanding, and then learning on the subject. Therefore, teachers play the role of 1) directly or indirectly leading students through their learning activities, and 2) intervening into students' learning activities where necessary so as to enhancing learning performance and achievement.

Support computer-supported collaboration among students.

Urhahne, Schanze, Bell, Mansfield and Holmes (2010) propose five principles to guide teachers in facilitating computer-supported collaborative inquiry learning: 1) envision the lesson by creating an image of the lesson, and planning and organizing student tasks; 2) enable collaboration by arranging small groups or pairs so that one can learn from the other; 3) encourage students by supporting learners and providing guidance during knowledge acquisition; 4) ensure learning by monitoring learning processes and checking learning outcomes; and 5) evaluate achievement by choosing suitable means to assess processes and products of learning.

Facilitate human interactions in ICT-enhanced learning activities.

Postholm (2006) suggests that teachers act as advisers in the ICT classroom through dialogues with students. ICT can mediate interaction between teachers and students to facilitate learning, but in the end teachers are crucial to make such interaction happen through guidance (Uibu and Kikas, 2008). Human interaction cannot be replaced by ICT and teachers play a key role in supporting interactions between and among students, in any ICT-enhanced learning environment.

Provide psychological supports to students.

Hardy and Kirkwood (1994) propose a number of roles for teachers when using ICT in tertiary education, some of which are also applicable to primary education: 1) develop the trust of students by affirming and supporting them to deal with their expressed doubts and insecurities when using ICT to learn, 2) enhance students' confidence by affirming students' ICT competence and valuing their acquired knowledge, 3) allow students to control their learning by letting them have significant control over the direction and pace on their own learning path, and 4) encourage reflection and sharing among students for tuning their critical thinking towards their own practices and justifying their perspectives.

Become an expert of study materials in class.

The introduction of ICT leads to a phenomenon that textbooks are less used in teaching than they used to be. Being less limited by such generalized teaching materials, teachers must deal with individualizing the learning process, taking each student's interests and abilities more into consideration (Uibu and Kikas, 2008). At the same time students rely more on teachers' instruction in the use of ICT. Teachers then become experts of study materials and function as the "gateway" to information sources found using ICT (Williams et al., 2000). There can be a challenge for teachers because, without being able to refer to textbooks, teachers may be expected to present knowledge of subjects accurately and effectively. This role as experts (at least in students' eyes) takes extra time to fulfil because teachers need extra analytical and synthesising abilities.

The above is by no means a complete account of the roles teachers may play in ICT-enhanced learning environments. And use of ICT in teaching and learning also leads to changes in the roles of teachers in non-ICT based teaching. For example, as Watts and Lloyd (2004) note, use of ICT may increase student autonomy in learning, and at the same time decrease teacher's control and authority. Therefore, teachers will need to develop new strategies to monitor students' learning activities to make sure that learning objectives are met.

3.4 Necessary and Sufficient Conditions to Support ICT for Teaching and Learning in Primary Schools

Integration of ICT into classroom teaching is a complicated process that requires changes in various aspects of the learning environment. In a study of ICT integration in Singaporean schools, Lim (2007) analyzed the necessary and sufficient conditions for the effective integration of ICT in the classroom and the supporting context of the school. These conditions include classroom management issues, availability of ICT tools, establishment of disciplinary and educational rules, division of labour among teachers, teacher assistants and students, and revised school policies. In this section, we will discuss these conditions in terms of policy and school leadership, curriculum, assessment, physical and technological infrastructure, and professional development.

Policy and school leadership

Policy-makers and school administrators need to apply strategies to address the various barriers to successful integration of ICT in the classroom, and support the creation of necessary and sufficient conditions for that purpose (Lim, 2007). Tondeur et al. (2008) point out that school-related policies, such as an ICT plan, ICT support and ICT training have a significant effect on classroom use of ICT.

At a national level, policies are needed to create a shared vision among school practitioners, to build a good physical and technological infrastructure, initiate industry-school partnerships, and provide training to teachers (Lim, 2007; Vallance, 2008). Lim (2007) proposes three policy recommendations on the national level to promote ICT integration in teaching and learning: 1) develop strategies for student ICT competency development in selected government and government-aided schools; 2) set ICT competency standards for teachers and students; and 3) redesign the mode of assessment and de-emphasize examination grades in order to optimize the potential of ICT for teaching and learning.

To execute national plans and government policies successfully, school-based ICT plans and policies are necessary (Gülbahar, 2007; Tondeur et al., 2007; Vanderlinde and van Braak, 2011). Tondeur et al. (2008) suggest five areas of school-level ICT policy that are key to the integration of ICT in the classroom: 1) ICT policy plan; 2) school leadership by the principal; 3) supporting conditions such as sufficient access to ICT facilities, skilled staff and ICT coordinators; 4) evaluation of ICT integration practices; 5) cooperation with other schools. Lim's (2007) recommendations for school policy stress the importance of a shared vision by all members of the school community; learning and sharing among teachers and staff; and setting up an incentive mechanism to encourage innovative practices. Throughout the process, school leadership is a key factor (Tondeur et al., 2008; Yuen, Law and Wong 2003). School principals are especially important as they are often the person who initiates ICT plans on both strategic and action levels.

Physical and technological infrastructure

The physical and technological infrastructure of ICT is a fundamental condition for implementing changes to use ICT in education. Setting up the infrastructure requires consideration of availability of physical infrastructure (e.g. rooms for

servers, computer rooms, placing of cables and network points, electricity supply points), ICT hardware and software, human resources to set up and maintain the infrastructure and support everyday running (Lim, Chai and Churchill, 2010). Lim, Chai and Churchill (2010) propose a guide for teacher education institutions to set up infrastructure and hardware that is also applicable to primary schools. Their guide includes description of some key components of schools' ICT infrastructure and hardware including networks, Internet access, computer rooms, open access rooms, staff computers, computers for students, and digital media production facilities.

Given sufficient ICT infrastructure for both teachers and students, schools need to have technical assistants and coordinators to maintain systems and ensure that the infrastructure remains compatible with developments in software (Divaharan and Lim, 2010). While technical assistants help to maintain ICT equipment and ensure everything works, ICT coordinators help to keep up-to-date with new innovations in the ICT field, decide the direction of ICT use for their schools, and organize in-school training for teachers (Lai, Trewern and Pratt, 2002). Through planning, allocating resources and budget, and giving technical and curriculum support, such coordinators lead the community of teachers in the integration of ICT-based teaching (Lai and Pratt, 2004).

For meaningful learning, ICT should not be considered only in terms of ease or efficiency when technology is advocated (Schacter and Fagnano, 1999). Both hardware and software need to be designed according to appropriate learning theories and pedagogical practices. Since different forms of ICT serve and augment different teaching and learning experiences, practitioners need to make informed judgments about which hardware or software is best suited to enhance student learning, achievement and the general ICT environment for the school. Software needs to be chosen or developed after considering the instructional strategy involved. For example, CD-ROM and DVD-ROM are well-suited to individualized instruction, but not necessarily for other types of pedagogy. Classrooms which undergo the transition stage from being traditional to being ICT-facilitated may face many pedagogical problems, such as lack of appropriate example materials, insufficient in-class practice, overloaded curriculum content, and disordered learning sequences (Lee, 2001). Well-developed software that is motivating, organized, and interactive can help structure ICT-facilitated learning activities, and also allow students to learn individually outside of class. Wassermann (2001) suggests that schools consider their hardware needs before implementing any ICT-based learning activities among students or teachers. The reason is that even when schools have sufficient resources to purchase different software products for teaching, their hardware is not necessarily adequate. Hardware is not limited to the efficiency of computers. Many ICT-based teaching and learning materials can only be best used within an environment with sufficient and appropriate hardware, which involves physical spaces, computer devices, audio/video appliances, and other equipment (e.g., special sensor devices for scientific experiments).

ICT curriculum

Various parties play a role in facilitating the development and execution of ICT curricula, including government, schools, and teachers. Many countries have official policies in place pertaining to the use of ICT to improve the whole system of education. A formal and compulsory ICT curriculum is an important part of these policies. A positive development of such curricula is when ICT changes from being viewed as a means of technical support, to having a role in pedagogy which stresses both teachers and

students' competences to use ICT for teaching and learning (Vanderlinde, van Braak and Hermans, 2009).

Curriculum goals in national policies need to be implemented through concerted plans and actions on the school level involving school leaders, administrators and teachers. As noted by Vanderlinde and van Braak (2011), an essential condition for ICT policy implementation to be successful is good communication between educational policy officials, schools and teachers, and having consistent information supplied to schools and teachers in order to link general ICT policy to local school level ICT policy (Jones, 2003). Especially when rapid changes are brought about by ICT integration in the whole curriculum, encouragement and support for teaching staff is indispensable (Divaharan and Lim, 2010). One potential problem in the process is that a proposed national ICT curriculum can become inconsistent with the one implemented at the school level. Tondeur et al. (2007) suggest that schools should pay attention to a few key issues to avoid this problem: a) the planning of the ICT curriculum across the school; b) the strategies to redirect education practices; c) access to courseware for ICT integration within the curriculum; and d) opportunities for professional development of teachers and staff. Pelgrum (2001) also proposes a number of principles for guiding schools in their assessment of the ICT curriculum: ICT-related objectives of the school, presence of teaching and learning practices, use of ICT applications by students, and so on.

While directions and standards set on the national and school level are crucial, adequate teacher competencies key to comprehending these standards and realizing them through classroom practices. It is important for schools to develop teacher competence, not only in basic ICT skills, but also in the pedagogical use of ICT and related management practices of the classroom (Hew and Brush, 2007). Since increasing ICT competence is a responsibility of school officials, teachers are suggested to participate in the process of ICT policy setting (Vanderlinde, van Braak and Hermans, 2009). As Olson (2000) suggests, rather than imposing new frameworks for ICT, a dialogue should be established based on parity between teachers on the one hand and innovators, researchers and policy developers on the other hand. "What emerges then is not an argument as to whether equipment, support or training is more important, but a much broader debate about mindsets, assumptions, beliefs, and values of individuals and organizations" (Tearle, 2003: 581). Curriculum reform, based on in ICT, is unlikely to succeed unless we understand teachers' personal perspectives and educational practices (Niederhauser and Stoddart, 2001).

ICT-based assessment

Integration of ICT in the classroom involves development of ICT-based assessment across the school curriculum. The practice of assessment and its effect on learning outcomes are influenced by the roles of ICT as defined by the school's ICT policy – whether ICT is considered as a set of skills, a vehicle for teaching and learning, or an agent for delivering other changes.

Effective use of ICT-based assessment may play a positive role in enhancing general practices of ICT integration. In this regard, both teachers' and students' experiences matter. A good way for implementing ICT can be based on the use of computer-based assessment tools under a specific assessment framework agreed and practiced by teachers. The reason is that if formal assessment is carried out via computer, teachers will need to incorporate some elements of similar tasks in their teaching to prepare students adequately; students may also be asked to practice

these computer-based tasks (McFarlane, 2001). Moreover, when students are stimulated to think about their learning process while using the assessment tool, ICT becomes learning-oriented and it is possible to examine students' action and thinking process. Thus the ICT-based assessment tool becomes a support to student learning by directing them to useful resources, rephrasing important questions, and providing additional information and answers to their questions (Miller, 2009). ICT-based self-assessment can also be used to help identify students' learning potential and their thinking strategies (Peltenburg, van den Heuvel-Panhuizen and Doig, 2009). Successful application of ICT-based assessment may facilitate students' positive attitude towards learning with ICT. For example, Lugosi (2010) found that Internet-based assessment used in group work contributed to students' positive attitudes towards ICT.

Considering the potential effects of both teachers' and students' experiences with ICT-based assessment, good design of computer-based assessment is of great importance. As Terzis and Economides (2011) note, social environment and the facilitating conditions are important for the use and acceptance of ICT-based assessment; and the effectiveness of assessment tools depends greatly on users' acceptance of them. Many studies find that students prefer computerized assessment over traditional methods because it is more credible, objective, fair, interesting, fun, fast, and less stressful (Croft et al., 2001). However, the results of some studies show that when ICT tools become more complex, the frequency of teacher and then student usage will decrease (Hsu, 2011). Therefore, the ease of use is crucial to a widely acceptable computer-based assessment tool.

Professional development

Professional development is needed for all school staff to support the process of ICT integration in schools. Teachers' competencies are of special importance. ICT professional development for teachers can be inadequate because the computer is traditionally often considered as a simple mechanism for delivery of course content, but not a mediation tool (Crook, 1994). This has led to situations where the use of ICT becomes limited by the course design itself. Littlejohn (2002) suggests several ways for professional development to help teachers incorporate new teaching methods with the use of ICT. Such professional development programmes aim to: 1) encourage focus on outcomes which can be evaluated;

Figure 3.8 Winners of the teachers' contest, Rahma Global Forum, Jordan

2) provide a practical introduction to educational theories; 3) develop project-based professional development in which academics plan students' activities in the course; and 4) offer ICT skills. Although professional development programmes are usually designed by academic educators, actual changes in pedagogical content knowledge start from teachers' perspectives and require teacher ownership, so consideration from the teacher point of view is often required (Rodrigues, Marks and Steel, 2003).

Similar to the development of ICT policy, localisation is also key to developing professional development programmes. Although both governments and school officials play a role in fostering ICT in education, the ultimate implementation relies on teachers in the front line, because successful implementation of ICT is eventually dependent on teachers' ICT skills and their intentions for ICT use (Divaharan and Lim, 2010). Primary schools often have limited availability of ICT resources, which may cause primary teachers to make less use of ICT, especially when they lack skills to make use of these resources (Williams et al., 2000). Innovation in education that is not directed at existing, down-to-earth school practices tends to end up being a failure (Fullan and Hargreaves, 1992). Therefore, professional development needs to be local- and context-based on specific subjects in particular schools (Shallcross and Robinson, 1999), so that the professional development is of intrinsic value to individual teachers (Rodrigues et al., 2003). As Williams et al. (2000) conclude, tailor-made ICT professional development needs to focus on the types of ICT resources actually available to teachers in school, and allow choice and guidance where it is needed by teachers who have different degrees of ICT literacy, and different disciplinary expertise.

A problem with ICT professional development programmes has been a lack of consideration of pedagogy for using ICT. Research (e.g., Loveless, 2003; O'Rourke, 2001) suggests the importance of focusing on pedagogy rather than on technology itself; and the need to innovate teaching styles when building teachers' ICT competences. One example of such innovative teaching practices is to have teachers engage in online forums during professional development. This can facilitate the development of ICT teaching, and teacher online communities which can foster both critical discussion and collegiality (Prestridge, 2010). Controversy, humour, personal experience and feedback all play positive roles in transforming teachers' beliefs about the use of ICT, and boost confidence for using ICT to transform traditional pedagogy. In the end, it is teachers' beliefs about ICT and education, and their understanding of the value and purpose of ICT, which will determine if and how they will use ICT in classrooms (Rodrigues et al., 2003).

4 Vignettes of innovative primary schools

In the previous chapters we looked into the basic historical, cultural, and educational premises that support our deep conviction that ICT has an exceptional potential to transform the learning processes of children in primary school. In order to systematically examine the phenomenon of ICT in primary education, we then studied the actual research literature and its most recent findings.

From the moment we started planning this project, it was clear to us beyond any doubt that if we wanted to really understand the whole context for using ICT, we had to establish intensive communication with real primary schools around the world. During the last decade, ICT has widely spread and is being exploited in many schools around the world in the exciting and innovative ways.

Figure 4.1 Learning beyond any limitations, S6

There is much to learn from schools, much to analyse, evaluate, and compare. We want to respect their rich innovative experience and support them in sharing it with others. We want to emphasize that it is not our goal to conduct a worldwide survey of the actual state of integrating ICT into primary education. Instead, we want to explore the changes that have taken place in schools where they have already seized the challenge. We therefore decided to establish a purposive sample of highly innovative schools, which are already able to reflect on the process of their transition.

In the first year of the project we identified nine such leading schools and invited them to cooperate. Each of them represents an exciting, unique and enlightening story. They are all different there are urban schools and rural schools, one very small school and some rather large, a school with only primary level classes, a school with excellent cooperation with a kindergarten, schools which prioritize their excellent relations with parents, with academia or with a private partner, a school that concentrates on activities for children of special education needs, etc. In this chapter, the schools will briefly introduce themselves and characterize their position on ICT.

Throughout our project we will conduct an intensive communication with schools concerning their process of change – in teaching and learning, in curriculum objectives and content, in relations among all the actors of the *ICT in education phenomenon*, and in the strategies they apply to make changes happen. In the second year of our study we will extend our sample to several dozen more of inventive primary schools from around the world – representing different cultures, traditions, beliefs, approaches, and different platforms for innovation. We plan to gather inspiring and representative data for further qualitative research about **how ICT can reshape the teaching and learning processes of children in primary education**.

We have asked the contact teachers of our cooperating schools to provide us with additional graphic material to illustrate all the chapters of this report. We present here various products of the pupils' expressing themselves with digital technologies, or photographs documenting how they exploit those technologies – inside their classrooms and outside, using computers, robots, digital cameras, etc. Additionally, we asked the children to visually express their relations to ICT by creating words and images on the theme of *'Computers and Me'*. Their creations can be found throughout this report. We plan to analyse these and similar visual expressions to better understand the children's feelings, values, and perception of their digital surroundings. It is impressive when one sees statements like: *Technology and me are one (S3) or I like computers because you learn nice things! (S7)*.

A complete list of our nine collaborating schools can be found in the Acknowledgements section at the start of the report, where we labelled them with reference codes *S1, S2*..., which we will use throughout the whole study.

ELTE Gusztav Barczi SEN Elementary School

The main feature of the Gusztav Barczi Methodical Centre and Educational Consultancy School for primary age children is to provide an educational environment for children needing speech therapy, guidance with learning difficulties, and developmental care for moderately mentally retarded children and children with mental disabilities, who may also need help with other disabilities. We are the practice school for future teachers graduating to become Special Education Needs (SEN) teachers and therapists. Our primary aim is to provide children facilities to express themselves, and different activities to enhance their abilities. Thus, classes are arranged with small numbers of children in order to differentiate developmental needs, and provide a **playful learning environment integrated with ICT tools**.

The interactive whiteboard is a well utilised tool integrated into several disciplines (mathematics, history, geography, language and informatics). Children are highly receptive to new technologies and experiences show that they are able to develop more intensively than with any of the other methodologies used so far.

Children learning in our school are not able to live up to the usual national educational standards, thus our teachers try to come up with special standards and developmental methodologies to suit the needs of their pupils. They have to succeed in writing up proposals to apply for grants that are very needed in order to equip the school with special tools to help their pedagogic work.

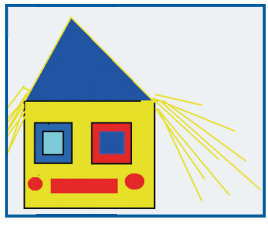
Our school has very close ties with the Informatics Faculty at ELTE University, due to a continuous cooperation in which informatics students develop special needs applications according to the needs of the school, with guidance from both institutions, and thus we get access to applications needed for everyday learning.

Teachers continuously take part in ICT courses for **professional development**, and build ties with international teaching communities with similar profiles in the Netherlands, Italy, Sweden and UK.

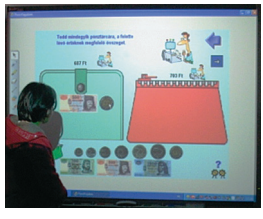
Computer and me

Creating sequences

Immersive engagement



Drawing: "A Clown house"



Counting coins

Box 4.1 S1, Budapest, Hungary

Princess Rahma School

We are an all girl public school in Jordan. As a government school we do not have large funds to invest and innovate, however, we have been able to differentiate ourselves from other schools starting with our vision: *We are looking forward to produce young leaders who are qualified, educated, creative and able to learn continuously using ICT in a safe environment competing with their counterparts locally and internationally*. We achieve our vision by:

- empowering our students as leaders;
- being open to new and innovative ideas;
- providing the students with much needed technical resources;
- providing our school with a variety of **professional development opportunities**;
- creating an environment which promotes 21st century skills among our students through communication, collaboration and connecting learning with real life experiences.

Through strategic partnerships with the *Jordan Education Initiative* (JEI) we have worked on introducing **innovative solutions in technology** and developing new ideas that involve our teachers, students and parents. Some of the innovations in our school are:

- personalized learning: one to one learning through use of the Intel Classmate PC;
- cooperation with local community by conducting educational workshops;
- recycling project: converting used materials and waste into useful products;
- conducting regular debates between our students on hot topics such as the use of social media, using the de Bono "6 hats" strategy;
- introduction of a number of digital media to improve skills, such as Rosetta Stone for learning English language.

This year 2011-12 we applied to qualify as an innovative school under the Microsoft PIL Innovative School Programme, and out of 200 schools applying from the entire world, we were among the 60 schools that got selected.

"One Laptop" initiative

In-classroom Technology using Smart Interactive Board

Collaborating with parents

Our children developing mental capabilities in arithmetic

Appreciating the value of Recycling

Box 4.2 S2, Jordan

American Institute of Monterrey

The American Institute of Monterrey was founded in 1968 with a great vision: to **AIM for Excellence**. In pursuit of this vision, our school developed a rigorous academic programme that is recognized locally and nationally for its excellence. Through time the AIM has also achieved recognition for its innovative endeavours as well as for its strong sense of social responsibility.

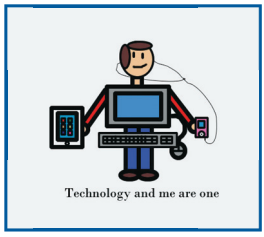
At AIM, under the i-PAL Systems (Innovative Personalized Attention and Learning – an educational platform), we seek not only to develop our students' academic potential, but to ensure that our students develop their knowledge and skills in four other areas: **Wellness** (social-emotional development, universal moral values, health and physical education), **Fine Arts** (voice, musical instruments, dance and theatre), **Sports** (soccer, basketball, track and field and Tae Kwon Do) and **Technology and Multi-culturalism**, thus assuring that our students receive a well-rounded education attuned to the 21st century.

Our school culture is technologically oriented to the global world in which we live. Our students use technology on a regular basis to create, inform and communicate, while in the process learning to respect and honour other cultures. Through our technology curriculum and its extension towards other curricular areas, students' technological work focuses on research and information fluency, creativity development, critical thinking and problem solving, communication and collaboration, as well as digital citizenship and technological operations and concepts.

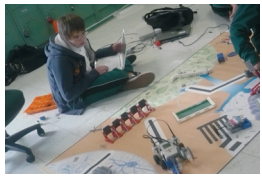
We are embarking on the process of taking our teachers, students, staff and parents by the hand to use technology as a Personal Learning Environment (PLE) and Network (PLN), with the aim to create educational networks where AIM members join with other communities to create, consume, remix and share material.

Student engaged in his project

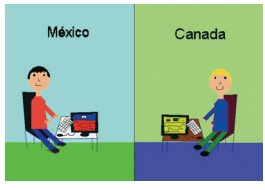
Students using iPods as a tool in learning



Child's view of technology as an integrated component of his life



Student immersed in robotics project



Child's view of technology use to bridge distances and bring people closer

Box 4.3 S3, Monterrey, Mexico

Technology of Education Centre

The centre is outstanding in its level of ICT integration in learning and teaching since our **students cannot visit school on a regular basis** due to their health conditions (some of them have cerebral palsy, others are visually impaired, etc.) and they learn at a distance in a Moodle-based environment. Students come occasionally to meet together, go to excursions, etc., and they are constantly using ICT.

Both at home and in the Centre, in all subjects and cross-curricular projects, the students do video and audio digital recording, interact via web-cameras, online audio and text messaging, scan pictures and texts, conduct experiments using digital measurements, compose music with Garage Band and play it with musical keyboards and Sound Beam, construct programmable LEGO robots, investigate physical and math virtual microworlds, and program in Logo-style.

In spite of fears, phobias, and uncertainty among parents, more and more parents are applying for their children to attend this Centre. Today the number of students is more than 150. The information environment, digital learning resources and **pedagogical approaches** are now used in many other schools. Our experience was the basis for introducing a new ICT-rich Federal standard for primary education into 1500 schools in Moscow.

An example of students' activity is the collective production of an animated movie *The Tsokotukha Fly*. The story (a fairy tale by Korney Chukovsky, written in 1924) is a tragedy (with a happy end) of the Fly, her friends, an aggressor – the Spider, and a hero – the Mosquito. The characters were made as beadworks; the animation was made as a stop motion film. The script, the music, the decorations – everything was made by children. Other children recorded a video of the process of movie making.

Constructing with Lego

Constructing objects

Music playing and editing with teacher

Video editing

Staging the fly

Box 4.4 S4, Moscow, Russian Federation

Beacon Primary School

Beacon Primary School is the first to be set up as a new elementary school in the Future Schools at Singapore program – FutureSchools@Singapore.

The future schools at the various levels are established as models for other schools for **innovative transformation of the education experience** that leverages on ICT. Currently, there are three future schools at primary level in Singapore. The aim of the Future Schools programme is to have a small group of schools to lead the way in providing possible models for the seamless and pervasive **integration of technologies into the curriculum** for engaged learning in schools.

The schools work closely with the Ministry of Education and Infocomm Development Authority to provide the necessary conditions for technology-enriched learning experiences for their students. Through a curriculum designed for engaged learning, the Beacon School prepares students for the Primary/Elementary School Leaving Examination (PSLE) at the end of six years of elementary education.

Our school started its operations and took in the first batch of students in January 2008. Recruitment of teachers started in December 2006. One of the selection criteria for staff was their past experiences of using technologies in their classrooms and also their passion for innovative educational practices. Currently, the school has a total of about 50 teaching staff and 960 students – 240 for each level (Grade 1 to 4). The school will ultimately reach a steady enrolment of about 1400 students with about 100 teaching staff in 2013, from Grade 1 to 6.

One of the significant innovations in ICT by the school is the one-to-one computing learning environment. The school takes a progressive approach by providing the necessary computing device (a notebook computer) to students in Grades 1 to 3. Students purchase their own computing devices when they are in Grade 4. All the current and pioneer cohort of Grade 4 students (2011) and **parents supported this initiative**.

FutureSchools@Singapore: Beacon Primary

Everyday Ritual
The School Assembly

Students engaged in an ICT-enhanced Learning Environment

Me and my computer!

Me and my computer!

Box 4.5 S5, Singapore

We are small rural primary school with less than 60 pupils, in a village of 1450 inhabitants. Though based in a two centuries old church building, for 12 years we are developing here a modern family school for productive life and happy contented children. We run only 1st to 4th grades – for children aged 6 to 10, nearly one quarter of them with SEN and 5 of them with mild mental disorders.

Although this picturesque school building has several maintenance drawbacks, our children are close to nature, both inside and outside as if "*at granny's house*". The school atmosphere and our achievements attract parents from the nearby town as well.

Being the first **Dalton School** in our country, we have founded the Association of Slovak Dalton Schools. In the Dalton activities and during the whole teaching/learning process we strive to build a positive and creative mood, which supports **joyful learning**. Our vision is responsible freedom of the pupils, self-reliance and collaboration: each child is an active, independent and creative learner.

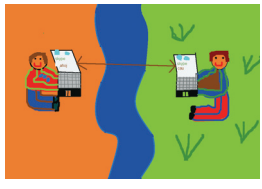
Our pupils learn in an **environment which is rich of digital technologies** that: are being used as a means to support our educational goals; help us to create innovative learning environments for children to experience opportunities for complex personal development; support higher order thinking and skills including communication, creativity and collaboration – in a joyful authentic atmosphere of self-discovery within learning.

We regularly run in projects involving ICT. E.g., in the *Journey to Fairyland* children in groups choose a folk tale, then **stage it and animate using Lego bricks**. They distribute the roles among themselves, elaborate the script, design and build the stage, light it, and finally use *stop motion animation* to capture the whole story frame by frame. They value the final product so much! Through it they boost their confidence and build a positive picture of themselves – beyond any expectations. It illustrates our strategy and goals of integrating ICT into their learning process in the most complex, seamless, productive and humane way.

Our little school with part of its yard and functioning belfry

In the classroom

Dalton activities on Fridays



Adam: Me and my computer

Stop motion animation with Lego

Box 4.6 S6, Primary School in Slovakia

St Andrew's Anglican School for Boys

St Andrew's Anglican School for Boys, founded 150 years ago is steeped in the Christian tradition and its motto *Fiat Lux* meaning "Let There Be Light" stands as cornerstone. The school is recognised widely for its strong academic focus, while preparing learners holistically to make a positive contribution to society and the work of life.

Accommodating about 760 language-diverse boys from many different cultural backgrounds, it comprises a Pre-Primary, a Primary and a High School, led by one headteacher.

The premises contain a hostel which hosts boys from all over South Africa as well as sons following in their father's, if not grandfather's footsteps a Chapel, sport facilities, a library, a museum, computer facilities, and classrooms with interactive whiteboards. Our classes do not exceed 25 learners.

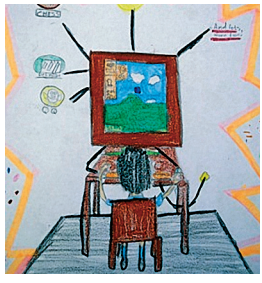
All learners visit the computer centre weekly. Although perhaps at a snail's pace, compared to the rest of the world, we are mastering computer skills by integrating the content taught in various subjects and allowing boys to use various forms of technology. This has proven to be an effective method for reinforcing concepts. Evidence shows that the **stronger the computer literacy level of the teacher, the more integration of ICT is allowed for in class**. Through peer coaching we narrow the generation gap among our staff.

Differentiation in the form of remedial support and enrichment is catered for. Learners have after-hour access to computer facilities and the Internet to complete projects.

As one of the school's outreach projects to the rural community, our computer club collaborates with the computer club of St Mary's School (a townships school serving a very low income community) during which we teach each other skills.

Working on my computer profile

A field trip to see how industries are using technology



My computer connects me to the world

We love to use the Interactive whiteboards

Sharing our computer facilities with other schools as part of our outreach projects

Box 4.7 S7, Bloemfontein, South Africa

St Richards CE Primary School

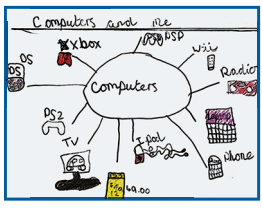
St Richards Church of England Primary School is in the Borough of Richmond-upon-Thames near London. There are 192 pupils between the ages of 3 and 11. The intake is mixed ability and, although St Richards is a Church of England school, it is a multi-faith school. Children speak more than 20 different languages; some arrive knowing no English at all. Over 25% of the children are eligible for free school meals.

ICT is used as widely as possible as St. Richards believes that effective use of ICT across the curriculum can enhance the teaching and learning experience. Each classroom is equipped with an interactive whiteboard linked to the teacher's computer, and a PC for pupils to use. Each classroom has digital cameras, video cameras and audio equipment, which are used by pupils to **supplement traditional written methods of presenting work**. Laptops are also available to use in whole class ICT activities, or for individual or small group interventions. These are housed in a mobile unit for ease of use in the classrooms rather than having a separate ICT suite.

ICT is used in five main ways in the school:

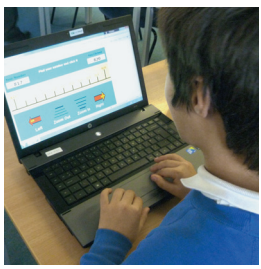
1. Staff use ICT as a **teaching medium** whereby teachers use the full range of ICT tools in conjunction with the interactive whiteboards.
2. In dedicated ICT clubs pupils learn touch-typing and how to **use basic tools** (Word & Excel).
3. Pupils use ICT as a **resource to research** information on the Internet to broaden their understanding of the curriculum subjects.
4. As an interactive teaching tool for students who need extra support in literacy and numeracy, we are working with the Institute of Education in London to develop interactive numeracy programs to reinforce specialist maths teaching and **improve understanding of basic maths concepts**.
5. "Fronter", a London-wide integrated learning management system, provides an interface that **enables communication** between members of the school community – teachers, parents and children – at school and at home. Apart from organisational use for timetabling and communicating information, the system is used by teachers to set homework tasks.

Report on the weather



Computers and me by Chloe, age 8

Computing in class



The interactive numberline

Box 4.8 S8, Richmond-upon-Thames, UK

Jamestown Elementary School

Jamestown Elementary School is a public school in Arlington, Virginia. Approximately 600 students, ages 3-11, attend this neighbourhood school a few miles from Washington, D.C. The school mission is to educate all children in an optimal learning environment, preparing them for success in a global society. The vision for technology use is to reach every student and **make learning engaging, relevant, and connected to real lives**. We accomplish this through actively engaging students in challenging learning experiences empowered by the use of a multitude of interactive and mobile technologies which inspire higher order thinking, creativity, and solving real world problems.

Digital learning is at the centre of pedagogical innovation. Classrooms are equipped with digital toolkits that include a variety of mobile devices, laptops, and interactive whiteboards. These digital toolkits enable students and teachers to select their preferred tools for learning; individualizing how students access information, collaborate, express their creativity, and share knowledge.

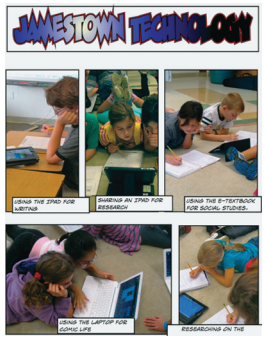
Digital technologies are integrated **across the curriculum** facilitating different ways of learning and providing immediate access to relevant curriculum resources. Students engage in challenge-based learning with multidisciplinary, collaborative learning experiences in which teachers and students work together to learn about compelling issues, propose solutions to real problems, and take action.

Through our digital connections, students participate daily in **global learning** linking them with students from around the world to carry out curriculum projects in science, history, geography, music, and world languages. Together with their international partners they **share learning, culture and customs that promote a global awareness** at a young age. For example, in the "Rock Our World" project, students from around the world create music together using digital recording studio software, share their experiences through digital movies, and communicate using online chat tools.

Global Collaboration via Videoconferencing

Age 8 – Creating an ebook

Collaborating on Assignments



Student-created Newsletter

7 year old working with an iPad

Box 4.9 S9, Jamestown, USA

5 National approaches to ICT in education

Most countries have now developed a strategic approach to ICT in education. In this chapter we set out the principles that are common to some of these documents, and identify the most interesting approaches to fostering the use of ICT in primary education.

The national documents we draw on for this chapter date from 2005. Many countries had ICT strategies in place prior to that, but they have had to be updated when technologies with new capabilities arrived. Not all countries are at the same stage of development of their ICT infrastructure: in Singapore and Qatar, for example, there is a very high penetration of ICT hardware and connectivity. However, although some countries may be further ahead than others in the process of ICT development, there is a remarkable similarity between the trajectories of change across all countries, whatever their stage of development. Aspiration follows where technological capacity leads. Change in education is primarily technology-led, therefore. We change what the technology suggests can be changed most easily; we do not necessarily harness new technologies to solve our most challenging educational problems.

We can see the evidence of this in the outputs from most educational sources. There are extensive text-based educational resources available in digital repositories because digital documents and Internet search engines make it easy to collect and provide them. However, while these are useful for people already in education, they will not serve our greatest needs. They will not make a significant impact on the UN Millennium Development Goal of universal primary schooling, nor will they address the needs of young adults who leave school with poor literacy and no employment skills. Therefore, while this chapter documents the important steps taken by national governments to promote ICT in education, it is not a wholly positive story. We should set these efforts against a consideration of what might have been.

Digital technology has transformed many professions in the public and private sectors. It has changed all sectors of education, in many countries. It has not yet *transformed education*. If we are to optimise the use of ICT in education it means showing who is master, recognising what the technology can do and harnessing it to the needs of education, not merely following where it leads. Interestingly, several national documents now reflect this idea: *Harnessing technology: Transforming learning and children's services* (UK, 2005); "harness the benefits of ICT for economic, social and cultural advancement" (Eritrea, 2005); "harnessing emerging technologies" (Kenya, 2006); *Harnessing ICT for future learning* (Singapore, 2008); "harness the power of ICTs to improve educational opportunities" (Australia, 2008); "harnessing ICTs innovatively" (India-Government, 2009), "harnessing the power of ICT to help young people realize their full potential" (Qatar, 2011). All these quotes show that national education leaders want to be in the driving seat of new technology. This chapter looks at the extent to which they are succeeding.

5.1 Common principles in national documents

The information reported here has been collected from national government websites, and we have selected a representative sample from all parts of the world. Three sources of information have been particularly useful: the World Bank "Master list of ICT/education policy documents"[36] dated April 2011, the EU Schools Network report[37], and the Survey of ICT and Education in Africa[38].

This section summarises the information extracted from each document in terms of (i) the agencies involved in development and delivery of the approach to ICT; (ii) the government-driven initiatives deployed to promote change; (iii) the approach to ICT in the curriculum; (iv) the digital tools, resources and services made available to education; and (v) the approach to teacher development with respect to the use of ICT for teaching and learning[39]. We have not included a section on "vision", or aims for ICT in education (although some of these are quoted in Section 5.3), because the overall aims are so similar across all nations. They can be summarised as:

> *to optimise the use of ICT in order to improve the quality, effectiveness, and accessibility of education in all sectors for the benefit of individuals and society.*

Similarly, there is no section on developing ICT infrastructure as this is a universal concern whatever stage of national development has been reached. In several countries there is now good provision in all primary schools, and in some (e.g. Singapore, Hong Kong) there is near-universal access at home as well. The increasing penetration of home access and mobile technology is beginning to shift government attention away from the provision of personal hardware in schools (e.g. the goal of low pupil-computer ratios) and towards provision of ICT services for home-based learning. It follows that governments will then have the responsibility for minimising the "digital divide" experienced in the homes of students of low-income families. This issue has not yet appeared in the current national documents. On the other hand, for those countries where the penetration of ICT into schools and homes is at an early stage, the provision of school-based technology infrastructure is a priority.

In the different national approaches to ICT in education there is not always a clear reference to the use of ICT in *primary* education specifically, but there is usually a focus on the school sector, with higher education and lifelong learning being dealt with in separate documents. A unified approach across sectors may become increasingly common, to provide a more seamless transition for students as they progress through their education: in 2005 both Eritrea and the UK had an explicitly cross-sector e-learning policy; the 2010 National Technology Plan for Education in the US is also cross-sector.

Recognising the universal aims for ICT in education, the ubiquitous attention to ICT infrastructure, and the focus on ICT in schools, the additional principles that national documents have in common can be highlighted in terms of the following critical headings.

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[36] see *blogs.worldbank.org/edutech/finding-policies*
[37] see *insight.eun.org*
[38] Farrell, Glen and Shafika Isaacs. 2007. Survey of ICT and Education in Africa: A Summary Report, Based on 53 Country Surveys. Washington, DC: infoDev / World Bank.
[39] In Appendix 1 we exemplify these key points through a selection of national strategy documents on ICT in primary education

The agencies involved

The agencies involved in a government's development and delivery of ICT are primarily the Ministry of Education, or its equivalent, with public sector education-oriented agencies operating at national and local levels. An interesting approach in Hong Kong is to designate schools that are successful in integrating ICT as "Centres of Excellence". India's State Institutes of Education Technology play a regional role in providing satellite broadcasting of educational programmes, and also in producing educational audio and video software for primary schools. Some countries involve other government departments with responsibilities for, e.g. science, the technology sector, and employment training. A critical delivery role may also be given to companies in the private sector, especially regarding ICT hardware, network connectivity, and educational software.

Government-driven initiatives

Government-driven initiatives are usually short-term projects to promote, or model, or seed activity in other agencies and in schools. One essential form of government initiative is to establish and maintain the technical infrastructure, as acknowledged in the introduction. Other types of initiative focus on the essential elements of a systemic approach to ICT that only governments can do: new approaches to curriculum, content and teacher development are common to all national strategies, although they can take quite different forms.

In addition, there are many areas in which different governments choose to initiate activities that are designed to make a significant impact on inducing change, such as to:

- Run a programme to raise public awareness of the value of ICT, and create equitable opportunities for students in kindergarten and primary school to access and utilize ICT (Eritrea).
- Introduce a "quality stamp" or kite-marking for the quality of multimedia resources (France).
- Develop a model school-based IT in education roadmap for schools' reference, and run workshops for schools on how to develop and implement the roadmap (Hong Kong).
- Provide ICT skills training for learners with special needs, and establish e-education networks for sharing educational resources (Kenya).
- Plan for the replacement of paper-based exams by digital exams within a few years (Norway).
- Introduce an e-maturity diagnostic and self assessment tool to measure how ICT is integrated and adopted in each school (Qatar).
- Establish a qualification for teachers and leaders in solving learning, cognitive and professional tasks with ICT (Russian Federation).
- Establish a network of educational labs for innovations, with educational technologists, curriculum specialists from the Ministry, experts and teachers (Singapore).
- Focus education research on "grand challenge problems", and use assessment data to drive improvement (USA).
- Run a "Home Access" project, targeted on the most disadvantage families, to provide access to appropriate technology to support learning at home for over 200,000 children (UK).

All these are initiatives that can only be undertaken by government, either because of their scale, or because private companies see no viable market for such activities.

ICT in the curriculum

ICT in the curriculum takes three forms or *models of implementation*, as specified in section 2.4: (i) ICT integrated across curriculum, (ii) ICT as a distinct curriculum subject, and (iii) Informatics (or Computer Science, Computing etc.) as a distinct curriculum subject. "ICT skills" often tends to focus on the use of standard applications rather than programming, which can diminish the potential value of ICT as a subject – young people are not receiving the stimulus and support that will interest them in careers that innovate and develop the digital tools and services of the future. Furthermore, a focus on programming and modelling skills is far more relevant to 21st century employment needs. ICT embedded within other topics typically exploits applications and access to Internet resources that are subject-specific. Digital literacy focuses more on the 21st century technology-related skills and competencies that all graduates will need, including the use of technology to assist with high level cognitive skills such as problem-solving, information analysis, design, etc.

National approaches to ICT in the curriculum, as for any change to the curriculum, are typically the responsibility of government, so this is addressed in all of the documents in our sample. A national curriculum approach may focus on the needs of the information society, as in Eritrea and India, but will also embed ICT across the curriculum, as in France, Hong Kong, Kenya, Norway, Russian Federation, Singapore, USA and UK, with most of these explicitly including the primary curriculum.

Not all countries have a national curriculum, and where development is decentralised, as in Australia, it is possible to focus on collaborative and consultative curriculum change as a more flexible response to the changing employment environment.

Digital tools, resources and services

Digital tools, resources and services are primarily the free software tools and resources that are available on the Internet, marshalled by government-sponsored specialist education portals or repositories. Some countries have planned to invest in the development of their own digital educational resources (Australia, Eritrea, Hong Kong, Kenya, UK). It is common to find plans for linking to open educational resources, now being provided by countries such as the US and UK for adult and higher education in particular. Open resources for primary education can also be found on the web, and of course teachers who are interested in technology are adept at doing the kinds of web search that yield pictures, videos and animations to enliven their teaching. However, development of educational software is difficult: for governments because it is expensive; for commercial companies, which do not see a viable large market because it has to be tied so closely to a national curriculum for teachers to use it; for teachers, because the software is expensive to buy or licence for the school, and they have little control over its content. There is a larger market for educational tools and services such as those provided by learning management systems, and this is where there is most innovation and development, while the interactive software that learners use remains a relatively small and under-financed enterprise.

Inclusion of services to the home (Hong Kong, UK) is rare, but as homes are increasingly equipped to support learning through ICT, this is likely to become a more common theme in national planning. This will improve the integration of the home-school learning environment.

Teacher development

Teacher development focuses primarily on equipping teachers with basic ICT literacy, although some countries want teachers to be able to integrate ICT into their pedagogy themselves, rather than rely on directives or pre-designed resources from others. In this case there is an intention to provide teachers with a deeper understanding of what ICT can do in education and to provide the knowledge building and sharing systems for teachers that will make them more knowledgeable consumers, and more skilled at making the best of available tools and resources (Australia, France, Hong Kong). A focus on teacher collaboration to foster the optimal use of ICT is a welcome approach given the complexity of what they have to develop. The curriculum for initial teacher training now often incorporates reference to ICT literacy, and where there is an emphasis on the importance of ICT in all curriculum subjects there is naturally a focus on this in the training. However, the teacher-training curriculum is not typically developed or taught by people whose main expertise lies in ICT-related pedagogies, because there has been so little time for such experts to develop. It is more likely that the personal development of this understanding will come through professional development rather than initial training, at least for some years. This is why countries that are leading the way, such as Singapore, the US and UK, are seeking to develop a "community of practice", a cadre of teachers with strong pedagogical grounding working as specialist teachers in schools to lead effective integration of ICT into the classroom and the curriculum.

Figure 5.1 A girl fine-tuning her robot

A teacher-led development of knowledge about how to optimise the use of ICT in the primary classroom would be valuable, alongside research-based studies. It has the important additional advantage that the knowledge and principles of practice are owned by the teaching community, and close to the point of use where they will have an immediate effect, rather than being disseminated top-down. However, there is little focus in any of the documents reviewed on providing teachers with the time to develop and innovate with ICT. Along with lack of training, lack of time is a frequent problem.

General points

Most national documents make no commitment to funding, and in many cases do not assign specific roles or responsibilities to organisations or units to put the ICT plans into action. In some countries it is possible to identify evaluation reports on previous plans, but there is often no specific programme for evaluation of the implementation. The extent to which these plans have borne fruit is hard to assess, therefore. What we can conclude reliably is that there is a clear intention, for a wide range of governments, to establish ICT as a critical part of the programme to improve and update primary education.

5.2 Harnessing technology to the needs of education

The overarching aim that unites most national documents is to optimise the use of ICT to improve the quality, effectiveness, and accessibility of education. Improving quality means enhancing the range of learning activities available to children to engage them in new forms of interaction , communicating, designing, and making, that the full range of ICT tools offers.

There is a strong desire in many countries to help all learners achieve their maximum learning potential. However, this is still a long way from being fulfilled, as the disparity between countries in the international educational benchmarks shows. ICT is seen as a way of enabling all learners to be given the kind of personalised support, and engaging forms of learning, that would make this feasible. At the broadest interpretation of accessibility this will include the UNESCO "Education for All" Goal and, for the countries in this survey that already have universal primary schooling, it includes access to better education for children who are disabled, or travelling, or for other reasons unable to attend regular schools.

The issues and approaches summarised in section 5.1 derive from a selection of 12 nations across the globe that have begun to put in place the infrastructure, digital resources, and teacher development that will make the use of ICT in primary education relatively commonplace. However, those activities alone will not necessarily harness new technologies to achieving our most ambitious aims for education. So in this section we look at what we know about what is needed for ICT to be effective, and test current national approaches against that.

The literature survey in Chapter 3 identified the policy requirements for ICT to be effective in serving the needs of education. Some of these – ICT infrastructure, teachers' professional development, and student and teacher competency standards in ICT – are covered in the headings listed above. We discuss here (i) the additional requirements at national level, (ii) the school-related requirements, which create a different kind of demand on policy-makers, namely, how to foster appropriate within-school strategies, and (iii) the planning for teaching and learning innovation that makes ICT effective at the school/classroom level.

Policy requirements

Of the three requirements identified for policy and leadership (student ICT competency, competency standards for teachers and students, and new modes of assessment), the first two are clearly addressed in the current national documents, but assessment reform less so. Formal assessment methods have to change to accommodate the new digital capabilities that students are learning, and it is now possible to assess learning through performance-based methods such as student portfolios, project-based learning, and activities that use ICT in a way that emulates real-world work, as in the publication from Eritrea.

Schools and students both focus on the requirements of the assessment system because this is the way they are judged, so ICT will only be seen as important if the assessment system uses ICT skills to evaluate learning (Tan, 2011). However, the references to assessment are typically to ensure that basic ICT competencies are assessed, which is not the same as assessing the ability to use ICT to learn, and to demonstrate what has been learned. This is like assessing the ability

to write rather than using writing to assess what has been learned. The focus should be on assessing what is important to measure, and making greater use of ICT to improve formative assessment and the use of digital data about learning performance, that can offer teachers a better understanding of what each student needs (cf. USA document).

There is also an interest in extending the capability of examining bodies to offer online assessment (Norway), although this is not so critical at primary level.

Chapter 3 outlines the ways in which a school's assessment policy has to change in order to accommodate the new skills students will have and the more challenging forms of assessment that ICT can offer. However, school-level assessment policy in most countries is strongly determined by national educational policy and by the assessment bodies that run exams, so ICT and assessment reform is effectively determined through national policy.

School-based requirements

The recommendations in Chapter 3 for what schools need to do for working with ICT include elements that can be encouraged by national policy, but must be implemented at school level: namely, development of an ICT policy plan, leadership from headteachers, access to ICT facilities and trained staff, evaluation of ICT integration practices, and cooperation with other schools. Critical to a national policy plan are the expectation for teachers to collaborate on innovation through a shared vision across the school community, with teachers learning and sharing their ideas, and with incentives to encourage innovative practices (Lim, 2007).

There are many such demands made of teachers and schools in the national plans we have looked at. However, it is hard to find one that addresses the issue of teachers' time to manage the change to this very different way of teaching and supporting learning. Training in ICT usage is only a small part of the overall teacher training programme, and the appropriate integration of ICT with schools' and teachers' wide range of activities is not an innovation that can be carried out as an addition to normal workload demands. This is important because studies have shown that without additional time and a link to personal reward, it is difficult to change teacher behaviour for any form of educational innovation (Dowker, 2003; Dowker, 2009; Griffin, 2004).

Curriculum requirements

It is important to distinguish the idea of learning *through* using ICT in a range of curriculum topics, also referred to as *e-learning*, or *technology-enhanced learning*, from learning *how to use* ICT in different areas, the latter being referred to also as *digital literacy*, which is seen as a core competence applicable to everything teachers and learners do. In many of the national planning documents the distinction in not clearly made, although both forms appear.

In the context of 21st century curriculum, "key skills" and competencies, policies often present the strategic aim of national economic growth as a driver for equipping all citizens and school leavers with the capability to understand and make good use of the many ways in which digital technologies can improve work, education, domestic life and leisure time. That in turn drives educational ICT policies towards equipping schools with infrastructure, tools and resources

they need to be able to teach digital literacy as a new skill. However, digital literacy is still is an ill-defined competence, as teachers and leaders realise that it should cover more than simply an ability to use basic IT tools and websites. Its real value is when the individual can identify novel ways of using and applying each new digital innovation, without having to rely on being shown what to do. The field moves too fast for education to teach everyone everything, hence the shift in focus from *ICT skills to digital literacy*.

Learning through ICT, or *e-learning, or technology-enhanced learning*, puts the focus on using technology to solve the difficult problems in education: learning difficult concepts and skills, or learning in a challenging context, or reaching the most challenging learners. Here the role that technology plays in the curriculum is pedagogic or logistical – changing the pedagogy to enable learners to learn in a more active, more collaborative or more engaging way, and changing the mode of learning to a more flexible (potentially online) delivery. Using technology to improve the quality and reach of education, or improve attainment levels, or increase attendance and access, means that teachers and education leaders must be able to use the digital tools and resources that they have in new and imaginative ways to help learners achieve what is impossible without the use of technology. This could be simulations of climate change, or space exploration, or running a shop, or writing a play – at primary level these activities can transform the kinds of learning activities that are possible, as Chapter 6 shows. These new ways of teaching demand a teaching community that is confident with technology, and able to innovate and learn from each other. That is why we have also focused on plans for teacher development, as that will drive the innovation and effectiveness of e-learning across the curriculum.

Factors affecting implementation

As we consider what it takes for new technology to make a significant improvement to primary education it is important to be aware of the very strong drivers that already exist in educational systems, and which have not been developed with respect to these new opportunities. Perhaps the most powerful are curriculum requirements, assessment, quality assurance mechanisms, and the way funding flows to different school activities. Learner needs will also be a high priority. These are issues that teachers and school leaders focus on every day, in the way a primary school is run. There are also pressures from "stakeholders", such as parents, school governors, and local administrators. And individual teachers will be aware of their own career opportunities as a motivator for their work. ICT is thus a minor element in the whole system by comparison with all these powerful drivers.

While drivers prioritise activities, teachers and leaders may be able to shape activities for themselves, and ICT can provide the capacity to do this. In practice, ICT impacts most clearly on teachers' and leaders' activities as a set of enablers to support their work to improve the quality of the learning experience, and their learners' achievements. Figure 5.2 sets out the main ways in which ICT enablers can improve the activities that are prioritised in the education system by the main drivers we have discussed.

The ICT-related enablers in Figure 5.2 are important precisely because the curriculum, assessment, quality standards, and funding imperatives are difficult for schools to change in response to ICT opportunities. Being embedded in educational systems and sectors, these key drivers are determined and

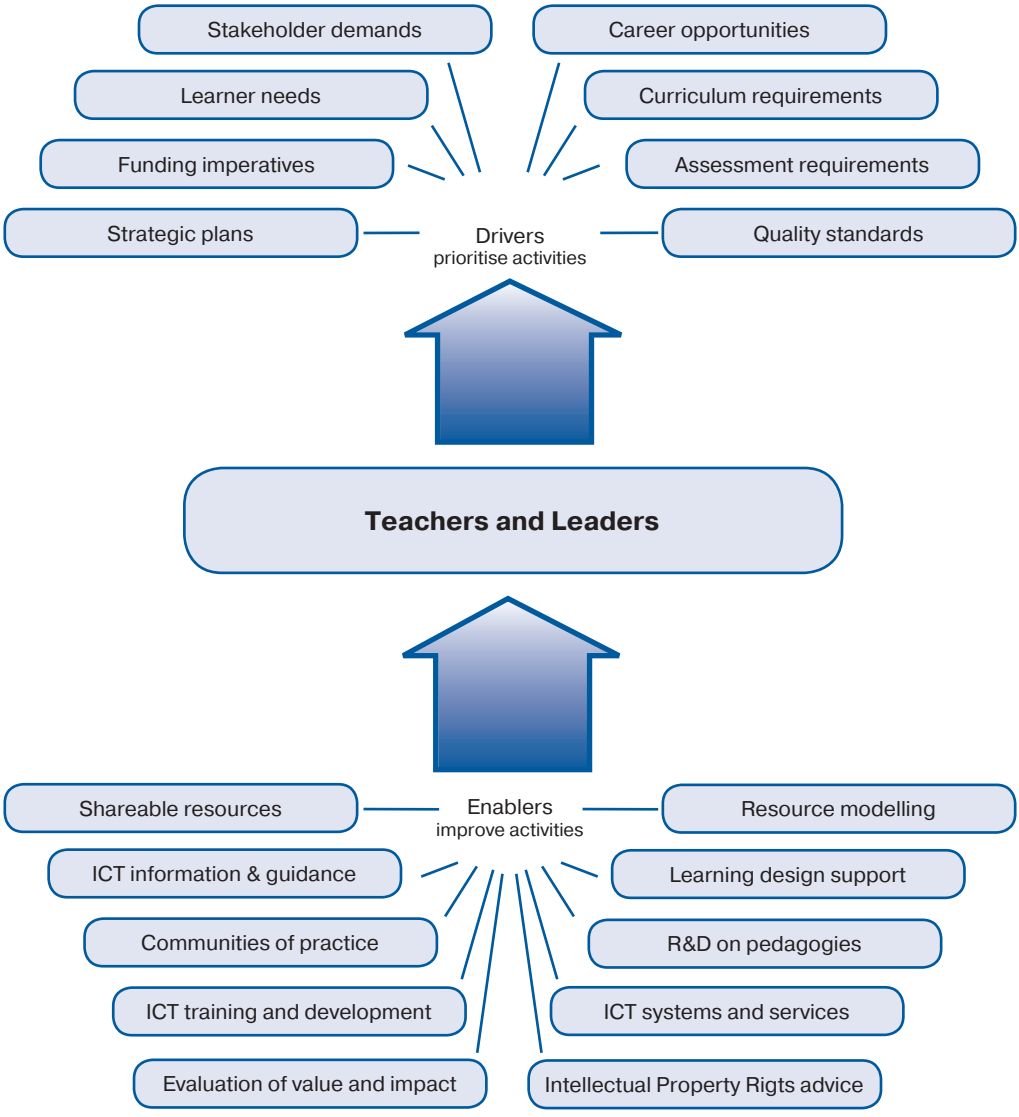


Figure 5.2 The drivers that influence the activities of teachers and leaders, and the ICT-related enablers that can be capable of improving their activities

revised by agencies, departments, and professionals that may not have any direct requirement to adapt to the continually changing opportunities offered by ICT. Thus, government initiatives are critical for leading this type of change. But also, the other forms of initiative discussed in section 5.2, putting in place enablers such as communities of practice, training and development, the ability to share resources, etc., make it possible for teachers and leaders in primary schools to effect some changes from the ground up. Both top-down and bottom-up enablers play their part in the holistic systemic change that is needed if the use of ICT is to fulfil its potential.

5.3 Quotes from the national documents

This section offers selected quotes from national ICT strategy documents in primary education, in order to demonstrate the range of current thinking at government level, as this responds to developing international understanding of the issues around ICT in education. Despite the diverse national origins of these planning documents, they have in common an expectation of the value of ICT in primary education, a sense of the importance of developing their own local content in addition to accessing international resources, and a clear understanding of the importance of engaging parents and teachers in the development of the optimal ICT-based learning experiences.

The expected value of ICT in primary education

Governments plan for the introduction of ICT into primary education because they have high expectations of its value, both as a personal benefit to the individual and as an economic benefit to the country:

> *The need to use new technologies to raise the quality and efficiency of education cannot be over emphasized. It is imperative that we expose our children, parents, and teachers to ICT to improve the quality of education and technical proficiency of our human resources, thus leading to increased productivity and accelerated development.*
>
> *(Namibia Government, 2004 : i)*

> *In primary and secondary education, ICT is considered as a transversal competence and is covered in all subject areas in the curriculum. One of the main goals of primary education is to "begin to use information and communication technology and develop critical awareness of the messages sent and received".*
>
> *(Medina and Muñoz Núñez, 2010 : 2)*

> *Web 2.0 will facilitate greater interactivity and user-generated content activities. It is crucial that young people acquire the ICT and related skills to take full advantage of these new communication interfaces and opportunities. Bolstered by ICT, the art of teaching can more easily facilitate personalised learning experiences which develop independence, self-direction and life-long learning skills.*
>
> *(Irish Government, 2008 : 2)*

Local content development

The international availability of open educational resources allows schools in all countries to access educational software and resources as a starting point for their teaching and learning. However, being entirely dependent on educational content that is created elsewhere would not be desirable, as it is important for the primary curriculum to be close to the local culture and priorities. This motivation to develop home-grown materials as well is apparent in many countries:

> *Mindset Network in South Africa has developed multimedia content directed by South Africa's National Curriculum Statement in new subjects like information technology for both primary and high school.*
>
> *(Farrell and Isaacs, 2007 : 25)*

Content developed by state funded projects and programmes will be deployed under appropriate licensing norms (like the creative commons) to facilitate open and free access to [ICT] resources... All public funded National and State level agencies will partner in developing, compiling and making available digital content, resources and tools. Norms for quality, universal open access for different types of digital content will be defined.

(India Government, 2009 : 11-16)

Publishing companies develop a variety of commercial products which are widely adopted in schools only in the case of Primary Education, especially among parents. Some actors in this market still regard making digital content production a profitable business as an open question.

(Medina and Muñoz Núñez, 2010 : 4)

As outlined in the NCTE's Digital Content Strategy, the three most effective approaches used in establishing a content pool for schools are "procure, build and share". The expertise of the teacher remains central to the development of digital content for Irish schools. Given the right supports and content creation tools, Irish teachers can contribute significantly to creating a first class content pool for the Irish curriculum.

(Irish Government, 2008 : 19)

Parental engagement

A learner's experience of primary education takes place in the contexts of both school and home. Some national plans for the use of ICT therefore place considerable importance on the role of parents. A school that communicates effectively with the home provides a greatly enriched learning environment, because it can support parents and carers in supporting their children's development, in a coherent way with the school's programme. Online communication makes this feasible, but only if the parents have the basic ICT skills that allow them to engage with the online school system:

It is recognized that parents play a vital role in supporting their children's education… [so] open classes for parents to develop ICT awareness and simple use will be offered. This may be through schools, libraries or community resource centres.

(Namibia Government, 2004 : 18)

It is our wish to take students, both young and older i.e. young people and their parents, on a train of knowledge that will offer them opportunities and challenges on every step of their career. Our objective is to provide them with the necessary skills to join the train of knowledge and to make use of the opportunities it offers.

(Slovenia Government, 2006 : 1)

Schools must strive to draw upon students' experience and use of ICT outside school as this forges powerful connections between ICT in the classroom, home and the wider world. School leaders should also exploit the potential of ICT to improve communication between home and school and to contribute to the development of school organisation and planning.

(Irish Government, 2008 : 12)

Teacher engagement

It has been a recurring theme throughout this chapter that ICT cannot advance in primary education without the engagement of teachers themselves. They are closest to the children and in the best position to discover how best to use ICT tools and resources as part of the everyday learning activities in the classroom:

> *ICT is compulsory in initial teacher education. Primary teachers must take at least a one-semester subject covering ICT in Education.*
>
> *(Medina and Muñoz Núñez, 2010 : 5)*

> *Beginning with an initial sensitisation through ICT operational skills and ICT-enabled subject teaching skills, teachers will become part of online professional groups (e.g. the English teachers association) to continue their education, pool in their resources and actively contribute to the strengthening of domain specific knowledge within the country… Teacher participation in the digital content development process will catalyse its broad-based usage in classrooms. Teacher capacities will be developed in instructional design, selection and critical evaluation of digital content, and strategies for effective use of digital content to enhance student learning.*
>
> *(India Government, 2009 : 11)*

> *In-service programmes at primary level have significantly lacked ICT integration to date. The National Council for Curriculum and Assessment (NCCA) review (2005) states that "the potential of ICT to support the aims and objectives of the Primary School Curriculum should be further exemplified for teachers, to support the development of children's concepts and skills in all subjects".*
>
> *(Irish Government, 2008 : 7)*

5.4 Concluding points

Our selection of national approaches to ICT in primary education has shown that across the globe, all governments have recognised the importance and value of digital technologies in education. There is not always a clear focus on primary education, but the sector is now being included much more explicitly in current initiatives. Children are often able to learn to use new technologies more readily than adults; they need active, creative, and collaborative learning tasks to be able to learn effectively, and ICT provides all these opportunities. Because of this, even in countries where the infrastructure is slow to develop there is still a plan to extend ICT provision to the primary sector as soon as possible.

The UNESCO *Education for All* Goal is a major global educational challenge. Digital technologies are good at solving hard problems on the large scale. If teacher development were to focus on digital literacy and collaborative development of innovative online pedagogies there could be a profound acceleration towards this goal. However, this requires funding resource to be directed at teachers, and it is actually more often diverted to hardware, software, and connectivity – which are essential, but technology does not need to be "high end" to be effective. National approaches feature insufficient teacher development, as we showed in section 5.1: the distribution of funding resource between human capacity and technical capacity always favours the latter. Teachers play the principal role in changing how effectively learners learn, and they need much better support to be able to harness technology to this end.

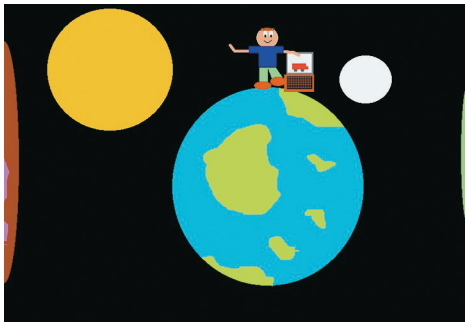
It is rare for any national ICT strategy to clarify the funding to be invested in this critical strategic change for education, and although agencies and organisations are identified as having a role in implementation, there is no national policy that identifies what that role should be, what milestones they are to work to, or by when they are to deliver. The *"ICT in Education Toolkit', (Information for Development Program)*[40] recommends that policies for primary schools should be organised around the need to:

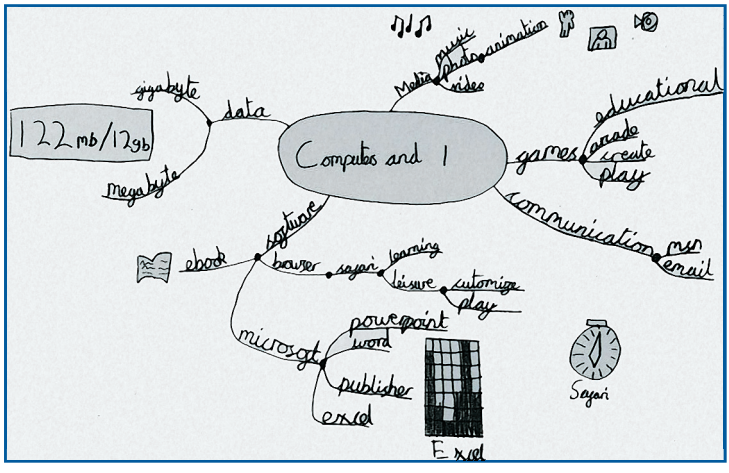
- *Formulate and Assess ICT-Enhanced programs;*
- *Plan for Physical and Human Requirements;*
- *Plan for ICT-Enhanced Content;*
- *Generate Programme Costs;*
- *Create a Master Plan;*
- *Monitor Implementation, Effectiveness, and Impact.*

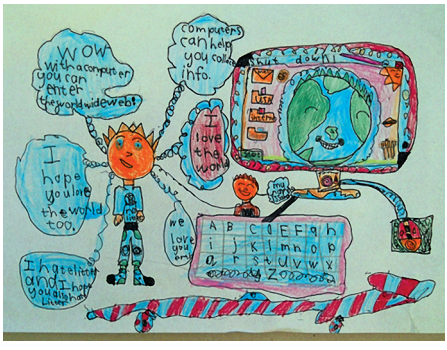
There is a general lack of attention to the fourth and sixth points, which means that there is not a clear link between funding choices and outcomes, and that whatever change takes place is not evaluated as it should be. Without attention to all six points, plans that are otherwise good will not be fully effective.

[40] see *www.ictinedtoolkit.org*

Computers and Me







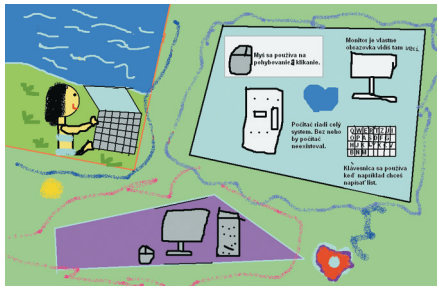


Figure 5.3 Digital technology empowers children – as experienced in Singapore, USA, Mexico, Hungary, UK, South Africa, Slovakia – and everywhere

6 Inspiring national and international initiatives and projects

In the previous chapter we examined how ministries of education and other official educational agencies have reacted to the evolving needs of society and employment in shaping policy and strategy on the use of ICT to enhance our learning processes. We believe that the overall picture presented by Chapter 5 (and its Appendix) has shown that across the globe, more and more governments recognize the importance and value of ICT in education for 21st century life and work.

Chapter 6 is devoted to presenting a rich selection of different national and international initiatives, networks, and projects that have been or are **successfully implemented** and could be of value to schools for inspiration, or even to join and participate in. All of the examples have potential for re-interpretation and scaling to different educational environments and conditions. Although not all of the examples are specifically addressed at primary education, our overarching aim is to provide a spark of inspiration out of real world experiences that might resonate with the reader's own needs and context.

What exactly do we mean by *national and international initiatives and projects*? Usually, they result from a situation where a personality or an organization, commercial company or institution – private, public or non-profit; regional, national, international or global – articulates a certain strategy, policy or vision and provides funding and other support to present it as an opportunity for schools, school leaders, school teachers, students, regions, or communities to harness the potential of ICT for development and innovation. If the leading organization is a government – and the initiative is not part of official national policy – then it typically acts as one of several partners who jointly put the vision into operation. Examples of such initiatives are the FutureSchools@Singapore Programme (see section 6.5 of this chapter), KwaZulu-Natal South African primary school project (section 6.7), and the Jordan Education Initiative (section 6.8) where the partnership is created through productive cooperation of a government, an industrial partner and an academic research body.

We have chosen to present projects and initiatives that:

- place **direct or indirect focus on ICT in (primary) education innovation**, (primary) teachers' development, or school networks;
- go beyond the scope of a specific teacher or school;
- focus on **practical implementation**, not only policy statement;
- promote 21st century skills and digital citizenship;
- have already gone beyond the design stage and already **produced evident outcomes, some or all of them sharable**;
- have already had certain impact in terms of **new digital pedagogies**, digital teaching and learning resources, scope (national or regional), beneficial perception, powerful partnership, geographical or cultural relevance;
- have already earned good reputation.

While official policies presented in Chapter 5 declare certain positions, priorities, needs or required standards, the initiatives presented here illustrate practical efforts to implement a certain change, process or a vision. They are diverse in scope and impact – from local activities that engage a small number of teachers or schools, through activities with apparent impact on a large number of schools, and ranging from short-term projects to schemes and frameworks having an ambition to continue and expand.

Some of the instances are international initiatives, which are entirely open for schools to participate. Others are designed around a particular geographical or conceptual context but their results are relevant to various educational settings. Here is the complete list of examples:

International or global open initiatives

- ISTE (International Society for Technology in Education)
- Microsoft Partners in Learning (PIL)
- Intel Teach Programme
- Shout

Initiatives developed in specific national contexts

- FutureSchools@Singapore Programme
- Plan Ceibal, Uruguay
- KwaZulu-Natal, South Africa
- Jordan Education Initiative
- Hungarian Sulinet/Educatio national initiative

Other projects and initiatives

- eTwinning
- iBeaver: International Contest on Informatics and Computer Fluency
- A Week in the Life – A Flat Classroom Project
- Personalisation by Pieces
- Hole in the Wall (Self Organized Learning Environments)
- iEARN (International Education and Resource Network)

There are dozens more similar projects and initiatives being conducted worldwide to promote richer educational experiences mediated by ICT. For reasons of space, we have not included other strong candidates like Fundacion Omar Dengo in Costa Rica or Smart Classrooms, a comprehensive strategy for digital education by the Queensland Government in Australia. It may also seem that we have unfairly neglected small local initiatives carried out by an innovative teacher with her or his students, or with a partner school. Note however that many such local projects are in fact particular activities conducted within a general scheme or platform, such as the ones we report on in this chapter.

6.1 ISTE

The **International Society for Technology in Education** (ISTE®) is a membership association for educators and education leaders throughout the world engaged in improving learning and teaching by advancing the effective use of information and communication technology.

ISTE[41] members include individuals, affiliate organizations, and corporations who support the vision of advancing educational excellence through innovative learning, teaching, and leadership. Together, this diverse community of educational leaders is **actively creating a world in which all learners can achieve their creative and intellectual potential**.

Through ISTE membership educators connect with peers, gather in a variety of forums to share the challenges and excitement of digital age leadership, teaching, and learning and are part of a community that leads the transformation of education.

Main Achievements/Impact

ISTE has developed a set of national standards for ICT literacy known as the **National Educational Technology Standards for Students** (NETS•S, 2007). These standards are designed to encompass the breadth and depth of ICT literacy and to be flexible enough to adapt as new technologies emerge. NETS•S strands include knowledge and dispositions related to: Creativity and Innovation, Communication and Collaboration, Research and Information Fluency, Critical Thinking, Problem Solving and Decision Making, Digital Citizenship, and Technology Operations and Concepts. NETS•S have been widely acclaimed and adopted in the U.S.A. and many other countries around the world, and are being used by schools for curriculum development, technology planning and school improvement plans. In addition to NETS•S, ISTE developed the NETS•T for teachers and the NETS•A for school leaders.

Table 6.1 shows six standard statements for students. Each statement is followed by indicators with additional description of what students should know and be able to do. For more information on the different NETS, visit ISTE's website at *www.iste.org*.

ISTE also hosts an annual conference and exposition. Each year in June roughly 20,000 educators, leaders, ICT professionals and corporate representatives from around the globe unite for five days of professional learning, collaboration, and hands-on demonstration of promising new technologies and technology-rich learning strategies for the classroom, school, and school district[42].

[41] for more Information, see www.iste.org, *www.iste.org/standards*
[42] see *www.isteconference.org*

National Educational Technology Standards for Students
Creativity and Innovation Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.
Communication and Collaboration Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
Research and Information Fluency Students apply digital tools to gather, evaluate, and use information.
Critical Thinking, Problem Solving, and Decision Making Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
Digital Citizenship Students understand human, cultural, and societal issues related to technology and practice legal and ethical behaviour.
Technology Operations and Concepts Students demonstrate a sound understanding of technology concepts, systems, and operations.

Testimonials

ISTE is not just technology—it's about teaching, it's about learning, it's about excellence in education and how we educate students for their future in the global society. ISTE has innumerable resources for you—whether it's books, webinars, connecting with people, learning and sharing. It provides a wide range of resources that will help you throughout the year.

Betsy Goeltz, ISTE Member and Principal, Pocatello, Idaho, USA

The work of ISTE is so very, very important. ISTE has been a leader in educational technology in all kinds of learning organizations, whether it's the pre-k12 environment or higher ed or community learning. By building a diverse and powerful membership base, they've been able to reach out across disciplines, across job categories, across leadership roles, and provide information, but more importantly, professional development training and networking that really takes our profession to another level. And that's the power of ISTE and the ISTE network.

Sheryl Abshire, ISTE Member and Chief Technology Officer, Lake Charles, Louisiana, USA

ISTE is able to provide for all kinds of learners, all types of teachers. There's something for everyone in this organization. If you want to take your professional development in lecture format, you can do so. If you want to learn in conversation, you can do so. If you wish to learn from demonstration or classroom exemplars, those opportunities are available. And I find that is the best kind of mix, and ISTE is able to provide that.

Peter Skillen, ISTE Member, Ontario, Canada

ISTE is important because it connects everybody from around the world. And it shows the importance of how we're not all separate people doing separate things in separate parts of the world. But we're all connected, and we have a common goal, and that is to teach, to provide educational opportunities to our children through technology.

Jill Benoit, ISTE Member and Vice-Principal
Technology Teacher, Newfoundland and Labrador, Canada

Figure 6.1 Student and teacher

Figure 6.2 ISTE members

6.2 Microsoft Partners in Learning

Partners in Learning (PiL in short) is one of the few initiatives that have worked on the concepts of education, innovation and technology at a worldwide scale with actual practitioners (teachers, and school leaders).

The programme has made serious steps towards dealing with the challenges faced in applied educational innovation, which are mainly focused around practices, people, culture and policy (and not necessarily focused on technology). The program has looked for advice through an international network of experts and practitioners from all over the world trying to find good practices and models to replicate and scale.

Recognising that the key protagonist of the learning process is the student, the program also recognises that sustainable efforts must be addressed at teachers, school leaders and schools as whole systems.

PIL has worked for several years on international projects with teachers – **Innovative Teachers** – and schools – the **Innovative Schools Programme**. And recently it has been involved in international research around teachers' practice (Innovative Teaching and Learning – ITL Research)[43] .

Innovative Teachers

PIL has made a big effort in building networks of innovative teachers with online resources and peer-to-peer interactions. An important part of the programme is a kind of "World Cup" for innovative teachers. Every year a group of teachers with valuable experiences is selected from different countries, who participate in local and regional forums presenting their projects. The best projects from each region are invited to a World Wide Forum in which the best projects from all over the world are selected and recognised by a group of international expert judges.

Figure 6.3 PIL Global Forum 2011, Washington D.C.: 200,000 applicants in regional events, 115 projects in D.C., 18 winners[44]

[43] more information at *www.partnersinlearningnetwork.com*
[44] *www.microsoft.com/education/ww/leadership/partnerships/pil/communities/Pages/global-forum-2011.aspx*

There is a clear impact on participating teachers, who are given a unique opportunity to meet and learn from peers who share the passion and enthusiasm to go beyond the limits of traditional education. But there is also a potential wider impact as these teachers become part of an online network, continuing the sharing of ideas. These teacher-led projects in turn become a rich source of inspiration for other teachers from all over the world.

Some of the teachers come from developed countries, but many come from deprived regions, having demonstrated incredible achievements with scarce resources.

Cheryl Arnett, a 1st and 2nd grade teacher had this to say: *Before going to the Innovative Education Forum and the Global Forum, I was totally unaware of the transformations taking place in classrooms around the world. Joining this inspiring global community of teachers has opened my mind to a feast of information and ideas that has no end.*

Innovative schools

It is often possible to find cases of innovative teachers that achieve impressive practices within their own classroom. But it is a harder challenge to find cases of whole schools in which innovation is part of all teachers' practices (and it is even more difficult to find whole districts or nations that embrace systemic innovation).

Figure 6.4 Silverton Primary School, Australia. A Mentor school that provides advice and support to new Pathfinder Schools

PIL has tried to find models and processes that might help schools to walk through a path of innovation. It has been clear for the program that this is a journey that takes time, involves multiple dimensions (curriculum, assessment, leadership, professional development, learning environments...), and where technology may be a supporting tool if the vision of school innovation is clearly defined and shared among all stakeholders.

The schools programme incorporates each year a new cohort of "pathfinder" schools selected from all over the world (60 schools in 2011), which are willing – and have demonstrated the potential – to undertake process of innovation. School leaders have access to support material developed by international education experts, they attend face to face workshops and online "virtual universities", and participate in a team composed of peers, leaders of mentor schools (selected schools from previous cohorts), and a team coach.

Schools have access to an online toolkit, which contains a collection of reference material, case studies and practical workshops that is available online at the website *www.is-toolkit.com.*

A primary school principal from Australia, Clayton Carnes said the following: *Thanks to Partners in Learning, we are a now a school of the world that just happens to be located in Australia. We can share ideas with anyone, anywhere – and I have access to the world's top education experts to help me lead innovation and change*.

For more information on innovative schools see also *www.pil-network.com/ about/ schools.*

Innovative Teaching and Learning (ITL) research

Together with the fieldwork done with teachers and schools, the program also aims at offering research-based information on how effective educational transformation takes place around the world. This international research is led by SRI International research lab, and involves collaborative work with research organizations in each of the participating countries.

ITL research is focused on teaching practices that have shown positive correlation with 21st century learning outcomes. The main findings and background information can be found at *www.itlresearch.com.*

Figure 6.5 Plaza – alternative learning space in the New Line Learning Academy in Maidstone, UK[45]*. The Plaza is devised to provide a higher degree of collaboration between teachers and pupils through an IT rich, flexible environment that promotes a variety of learning settings*

[45] see *www.futureschoolstrust.com/cornwallis or www.worldarchitecturenews.com/ index.php?fuseaction=wanappln.projectview&upload_id=11201*

6.3 Intel® Teach Programme

Intel Teach was launched as part of the Intel Education Initiative, with the purpose of improving teachers' effectiveness by providing them with a professional development programme, helping them to integrate technology into their lessons and **promoting students' "21st century skills", including problem-solving, critical thinking, and collaboration skills.**

Since its launch, Intel Teach has reached more than 10 million teachers in 70 countries[46], and proved to be unique in terms of its scale and contextual adaptability. In terms of its aims and instructional design, the Intel Teach program supports 21st century skills and deploys project-based approaches and multiple forms of assessment for learning that are aligned with recognised educational standards. The programme can be offered online for self-learning and personal professional growth, as well as supporting integration of the programme into online and face-to-face professional development programmes offered with a set of facilitation material. In both cases the programme includes animated e-learning tutorials, interactive exercises and offline activities to apply concepts into practice.

Teachers attending Intel Teach training are provided with knowledge to help them transform instruction to engage students with appropriate use of technology, Web 2.0, and social networking to foster learning, creativity, and communication. There is an "Assessing Projects" application with a library of teacher-created assessment resources. The programme guides K-12 classroom teachers to integrate technology tools and resources into their own lessons, promoting 21st century learning and student-centred practices, particularly project-based learning.

Intel Teach courses are challenging and have immediate practical impact on teachers' work. Course curriculum is refined through extensive evaluation, and independent research has confirmed measurable changes in practice and high participant satisfaction.

A study was conducted by the *Jordan Education Initiative* (JEI), entitled *Qualitative Study of Intel Teach Programme In Jordan* to assess the impact of implementing the Intel Teach programme in Jordan, which was the first country in its region to adopt the programme, and approximately 68,000 teachers have up to now received the training. The evaluation study showed the following findings[47]:

- three key reasons for taking the Intel Teach Program emerged in this study: 1) incentives; 2) reputation of the programme as one that is relevant to teaching; and 3) the logistics of taking the programme make it easy for teachers to attend and participate;
- teachers are realizing the need to change their role in the classroom in order to instil different skills in their students while learning.; teachers are beginning to see the impact of technology on their students' learning and classroom environment; there was a consensus among teachers that **the program had made a shift in their teaching from being teacher-centred to student-centred**;

[46] find more details at *www.intel.com/about/corporateresponsibility/education/*
[47] for more details refer to the full report by JEI at *www.jei.org.jo/#/4*

- almost all teachers acknowledged the importance of project-based learning as an integral component of the Intel Teach Program (and some good examples were captured); the Intel Teach Programme provided teachers with ideas and skills that make the use of ICT in the classrooms more efficient and effective;
- the teachers gained skills that they could transfer to their students in the classroom; it was found that the students developed critical thinking, problem solving, team work, project-based learning, and creativity skills, as well as became very competent in using computers and applications, and navigating the Internet;
- teachers showed good **classroom management strategies** and were able to create an interactive environment; the teacher's competency in using the technology played a big role in their mobility in the classroom, to attract students' attention and keep them engaged in the lesson;
- there was an emerging seed for communities of practice between teachers who took the programme; through these communities teachers have found an opportunity for interdisciplinary teaching and to design lessons with other teachers;
- applying the concepts and the knowledge gained from the programme did not come without challenges; teachers mainly mentioned access to computers at school and at home, computer specifications, and teaching load as the main barriers to effectively applying the concepts in their teaching.

6.4 Shout

One of the best approaches to develop 21st century skills – such as collaboration, innovation and critical thinking – is to engage in authentic settings that require the practice of such skills.

Shout[48] is an international initiative that invites students from all over the **world to explore, connect and act to address some of the world's most pressing environmental issues**.

Students are provided with resources and tools to work together on projects aiming at making the world a better place. The initiative is a collaborative effort supported by the Smithsonian Institution, Microsoft's Partners In Learning Network, and TakingITGlobal.

Some of the online tools and resources available to participants are:

- Online events hosted by the Smithsonian Institution.
- Scientists and leading experts bring diverse perspectives on environmental issues through online sessions.
- Access to the Microsoft Partners in Learning Network Global community of innovative educators that share resources, experiences and best practices.
- Engagement of students in TakingITGlobal's online community.
- An online community with resources, tools and collaboration spaces designed to deepen environmental understanding.
- A web portal that ties together available tools and resources.
- *Student challenges* provided through the portal on which students can get involved and participate in activities that range from capturing and sharing scientific data to developing student-led initiatives for positive change.

Shout had an initial focus on land environment issues. One global action project on which students decided to participate was DeforestACTION. This is an initiative to reclaim native forests that are at risk of destruction and exploitation for the production of palm oil.

Figure 6.6 Students working on environmental challenges

[48] see Shout web site *shoutlearning.org* and deforestation site *dfa.tigweb.org*

6.5 The FutureSchools@Singapore Programme

The FutureSchools@Singapore (or FS for short) programme aims to **transform teaching and learning practices through the use of ICT** by providing a platform to set in motion innovative transformation of the education experience in Singapore[49]. Schools in this programme engage in research, experimentation and implementation of a wide range of ICT-embedded and pedagogically-sound practices that will eventually lead to **whole-school adoption**. These practices, and more importantly the associated success conditions, are evaluated and judiciously implemented in other schools where appropriate. This way, what starts off as research-informed ICT pedagogical development becomes translated into practice within a well-supported environment, and subsequently propagated through the school system as a tested and proven way to enhance teaching and learning. One of the main motivations for this approach is the recognition that a concerted and focused effort may bring about "breakthrough change", where ICT is pervasively used for teaching and learning; and as a result, it is then more likely to gain meaningful traction within the education system. It is anticipated that the FS programme will give a strong step-up in the **evolution of ICT ecology in schools and among school leaders and teachers** in Singapore.

Figure 6.7 Students and computers at S5

The FS programme is a collaborative effort leveraging new and existing technologies from computer hardware and software industries, and the pedagogical experiences of educators and researchers. Thus, each school selected for the FS programme works with a **consortium of industrial partners and educational researchers**. The tripartite relationship provides a platform for each partner to contribute and grow its own capacity, allowing for a mutually beneficial iterative learning process. In June 2008, five schools that met the stringent selection criteria were selected and formed the first batch of schools under the FS programme. These criteria include a strong commitment by school leadership to the FS programme, the soundness of the proposed pedagogical approaches, capacity of the teachers engaged in the project both

[49] see more at *iresearch.edumall.sg/cos/o.x?c=/iresearch/pagetree&func=view&rid=98*

in terms of research and teaching experience, and clear articulation of how such integration of ICT into teaching and learning can take place. To support these five schools, a total of S$80million was made available by the Infocomm Development Authority of Singapore (IDA), the National Research Foundation and private industries over four years (IDA, 2008). Lessons learned from the work of these five schools will inform and shape the subsequent participation and practices of other schools in this programme. The aim is to have eventually up to 15 FS schools.

The success of the FS programme is not just dependent on the abilities of the various partners in integrating ICT into teaching and learning. A key factor is the **leadership provided by the principal and the department heads** in each school. It needs this leadership to both articulate the direction, and create the conditions and culture that are conducive to the adoption and use of ICT. In other words, the school leadership needs to take ownership of the project, and this is reflected in each school principal taking up a Principal-Investigator (PI) or co-PI role in the FS projects. As for teachers, it is not enough to have ideas about how to use ICT, but also to be sufficiently grounded in related pedagogies and assessment to make the engagement meaningful. This requires teachers to continually update their knowledge and reflect upon their own practice in the teaching and learning environment. This whole-school approach forms an important tenet of the FS programme and highlights the importance of practitioner research to support such efforts.

6.6 Plan Ceibal, Uruguay

Uruguay is a relatively small Latin-American country that has recently been recognised for the audacity of a nationwide 1-1 computer programme.

Over recent years there has been a large debate on the needs, benefits and costs involved in every child having access to a personal computer. This debate was triggered primarily by the movement that was initiated by Nicolas Negroponte and the OLPC (One Laptop per Child) Initiative.

The promise of accessible low cost computers (at the price of approximately US$100) and the transformational power of these new tools in the hands of children made many countries to consider the massive acquisition of such technology for school children.

Uruguay is one of the countries that took the challenge and initiated a nationwide program called **Plan CEIBAL**[50]. In 2006 former president Tabaré Vasquez made the political commitment that *every student and teacher from a public school in the country would receive a free portable computer*.

The programme is presented as being focused on digital inclusion, aiming at equity and social justice. And the impact in this dimension is clearly achievable since Uruguay – like many developing countries – has a social context in which the majority of children would have no access to ICT if it were not through these types of public efforts.

There are clear educational expectations, and this is a harder challenge than the one faced from a social inclusion dimension.

Figure 6.8 Students, from rural areas, who have received their laptop from Plan Ceibal

[50] see the initiative portal at *www.ceibal.org.uy*

Teacher training, educational content, and technology integration into teaching practices are some of the dimensions that any educational technology programme must address in the long term and the world is observing how Uruguay is implementing these challenging aspects and the long term impact it might have on the quality of education.

The political will and the courage taken by Uruguay in this program has to be highlighted. Many countries are debating whether to follow a similar approach and it is suggested to follow Plan Ceibal process and learn from their success and mistakes.

Figure 6.8 Students, from rural areas, who have received their laptop from Plan Ceibal

6.7 KwaZulu-Natal, Lakeside Park Primary School, South Africa

In 2010, teachers in Grades 1, 2 and 3 at Lakeside Park Primary School in the village of Vryheid, in rural KwaZulu-Natal were the first to experience the excitement of using Xbox Kinect technology in a South African classroom. With the long term objective of increasing literacy levels of second language English learners, Microsoft commissioned SchoolNet South Africa to install a 55-inch television screen and Xbox Kinect in each of the six early grade classrooms.

Figure 6.10 Good sportmanship developed amongst learners

The teachers gave up their January holidays in 2011 to work through a professional development programme conducted by Peter de Lisle of Hilton College and SchoolNet SA who focused on the teachers' role of mediating learning through Kinect games. These primary grade teachers readily embraced the technology that was intended to **stimulate discussion, provide vivid learning experiences and spark ideas as well as creative and critical thinking in general**. Once the academic year commenced, teachers collaborated in grade groups to develop specific, workable plans for incorporating Kinect games into lessons that aligned with the curriculum that had been determined at the end of 2010.

The language of learning and teaching at Lakeside is English even in the early grades, despite the fact that the home language for the majority of learners is Zulu. This is the decision of the parent body, which contradicts language acquisition research and is an extreme example of the legacy of Apartheid history. Many learners have not spoken English before entering Grade 1, not even informally in the playground.

Figure 6.11 Gaming allows learners to master a new language through technology and physical activities

The evaluation of this intervention is yet to present its findings officially but early anecdotal evidence indicates a significant increase in literacy as well as numeracy. Although the Xbox games require learners to move vigorously and to talk (and more often to shout) there is almost no reading involved and yet there has been a **noticeable increase in reading levels**. This result can be explained by the fact that reading skills are strongly influenced by learners knowing how to sound out the words when learning to read.

The huge challenge facing teachers was to create learning experiences which helped to bridge the language gap, rather than exacerbate it. The teachers at Lakeside harnessed the potential of Kinect's English-based games to involve the hesitant young learners in trying the new language. The Deputy Principal, Karen Kirsten explains:

> *Shy learners, who take months to speak up in class in their mother tongue – let alone in English, were already shouting out to classmates to "jump" and "duck" with no inhibition. In inspiring the learners to interact with their classmates through the creative gaming and learning exercises they seem to engage with the games so intimately that they seem to overcome their early inhibitions inadvertently and so, can learn more readily.*

The games give teachers scope to allow a wide variety of learning styles to come to the fore. Karen Kirsten tells of a partially deaf learner, who previously had to repeat the previous year, and yet scored the highest marks in class on the first day of school by "acing" the Xbox dance game perfectly.

Through this project, it is evident that gaming technology such as that being used in Lakeside Park Primary can be used effectively to unlock a new world of learning and particularly for those learners who have special barriers to overcome whether it be with literacy or numeracy.

Figure 6. 12 Teachers use Kinect to drive heightened engagement in the classrooms

6.8 Jordan Education Initiative

Developed by the World Economic Forum (WEF) and the Government of Jordan, the Jordan Education Initiative[51] (henceforth the JEI), incorporates over 17 global corporations, 17 Jordanian entities, and 11 governmental and non-governmental organizations as stakeholders in achieving its goals, thus becoming the first Global-Local, Public Private Partnership programme in education, ever launched by the WEF.

Launched in June 2003 at the Extraordinary Meeting of the World Economic Forum at the Dead Sea, the JEI was set up to **accelerate education reform through public-private partnership models that drive innovation and capability**.

Figure 6. 13 Students engaged in the team activities

By the end of the its phase one (2003-2007), the JEI has managed to foster and maintain partnerships and had launched multi-million dollar projects that had strong impact on the modernization process of education in Jordan, and had effectively contributed to the development of the local private sector in areas of ICT and Professional Development. Key achievements of this phase were:

- ***Development of e-Curricula:*** Six electronic subjects (comprising 3,373 e-learning lessons) were developed from scratch based on the national curriculum, including: e-Math, e-Science, e-English, e-Arabic, e-ICT, and e-Civics. Adopting a blended learning approach, the JEI uses these e-curricula as enrichment tools to support teaching of the national curriculum and to shift the learning process towards a student-centred approach. All e-Contents are deployed on the Ministry of Education national portal (EduWave).

- ***Teacher Training:*** For effective deployment of the JEI materials, the JEI, together with the government of Jordan, set out to provide teachers in the participating Discovery Schools with basic ICT literacy programs, as a first step. A general policy was issued by the MoE that required all teachers in Discovery Schools to take the International Computer Driving License (ICDL) Course, as well as other available courses such as Intel Teach and World Links.

  Each content developer was also responsible for creating a training programme for its products. Therefore, each product is accompanied by a subject specific training (SST) package for how to use that particular e-content, which teachers take upon successful completion of the basic ICDL training. To assure continuity and sustainability, the JEI made sure Ministry of Education staff were fully engaged, and that the Ministry-employed trainers received “Train the Trainer” courses from the content developers.

[51] see more at *www.jei.org.jo*

Believing that principals and teachers are key for an overall effective environmental improvement, the JEI continues to build relationships with high profile educational and professional development institutions to continually launch professional development opportunities.

- ***Technical infrastructure:*** all 100 Discovery Schools were provided with wireless access points, a minimum of 2 computer labs to be used for teaching e-content, and innovative in-classroom technology solutions (laptops, projectors, Interactive white boards. etc). These providing 80,000 students and 3000 teachers with opportunities to research, communicate and use modern teaching and learning techniques.

Today, the JEI has become one of Her Majesty Queen Rania Al Abdullah's Not-for-Profit companies working with the Ministry of Education in driving innovation, through leveraging private sector participation. JEI's work is categorized under three main tracks:

- **Discovery** – Piloting new innovative solutions and new partnerships
- **Expansion** – Rolling out through Madrasati (Queen Rania's companies)
- **Global** – JEI services offered to local/global private sector and governments

Track 1: Discovery

The quest for innovation and continuous improvement in education never stops and the Discovery Schools, which are fully equipped with the model technology, can serve as test beds and venues for attracting and piloting further innovations. The JEI actively researches in areas of innovation, and seeks to create new international and local partnerships and scope new projects. Each project is based on a partnership and gets implemented using Project Management Institute (PMI) standards in discovery schools. To make sure the projects achieve the desired outcomes, a set of key performance indicators (KPIs) are identified, and the project is monitored and assessed throughout the implementation process. Project results are summarized in a report that is shared with all stakeholders.

Figure 6.14 Students at the Discovery Schools using modern technology

JEI pilot projects (so far, 31 projects in public schools in Jordan) include various partnerships and a broad range of technologies, aiming at communication, planning, ICT skills, and presentation. These Pilots are well received by schools, and contribute to the overall improvement of each school.

Track 2: Expansion

The JEI's experiences with partners and technologies have resulted into a comprehensive JEI model for education using technology (Hardware and Software), training and change management. Through further strategic partnerships, JEI has been able to raise funds to roll out the model in another 100 Schools distributed throughout the kingdom.

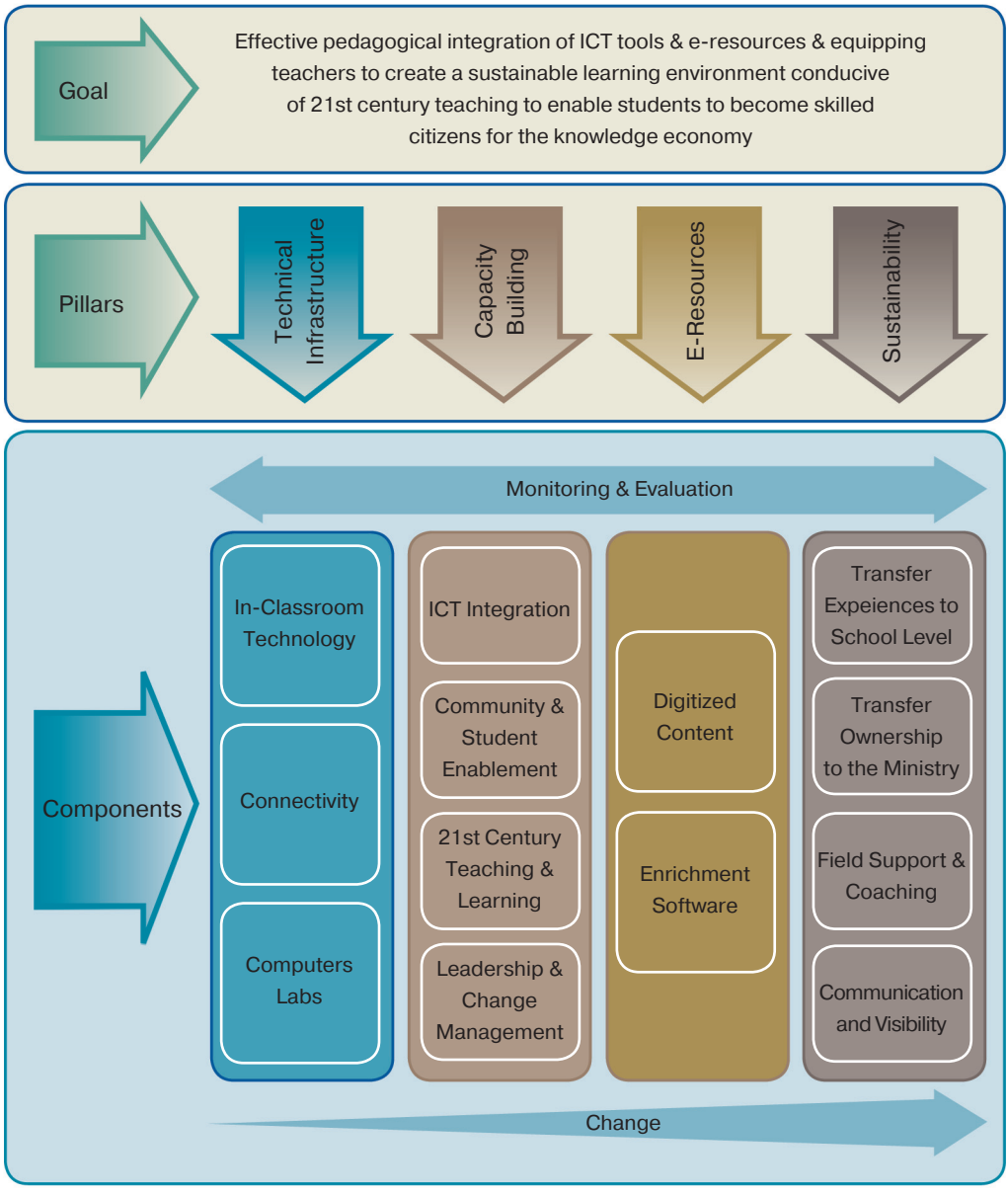


Figure 6.15 Jordan Education Initiative's Educational Model

Track 3: Strategic Partnerships and Global Outreach

A strategic goal of the JEI, since its inception, is the creation of a model of reform and partnerships that can be promoted and shared with other countries around the world. Therefore the JEI actively participates in regional and international conferences and forums to promote the JEI model and projects, to generate interest in other countries. The JEI has set up a consultancy arm that can manage and implement projects abroad.

6.9 Hungarian Sulinet/Educatio Initiative

Applying ICT in education as well as supporting the pedagogy for developing digital literacies defines more than a decade of work for Education Non-profit LLC, and previously the Sulinet (School Net) Program Office. The Sulinet portal (1999), and Sulinet Digital Knowledge Base (2004) provide constant and reliable resource for the stakeholders in learning and teaching in primary schools. Apart from offering digital content and information, a lot of projects have been initiated in recent years that support teachers' work with pedagogical-methodological best practices and for the development of technology applications.

ICT workshop 2008

Digital learning materials, interactive whiteboards and learner response systems bring methodological changes to classroom teaching/learning processes. In 2008 an ICT workshop was held to show authentic and progressive classroom practices, to generate ideas, and to give teachers applicable methods for developing digital competencies. During the workshop 14 ICT-supported activities were followed in live video broadcast by more than 100 participating specialists. Activities were led by innovative teachers with different ICT fluency levels, who worked with different student groups. During the phase of professional testing, workshop participants could debate lesson plans, methods and tools used in the classroom. The workshop resulted in an *ICT Workshop 2008* publication[52] on a DVD that contains recorded workshop activities, lesson plans, summaries of discussions, feedback and propositions for development, and also related learning resources taken from the Sulinet Digital Knowledge Base.

ICT workshop 2010

In the e-Learning Professional College project Educatio LLC initiated a call for applications named **suli.net.tan**. Applicants were future and practicing teachers who produced descriptions of pedagogical best practices and ideas for their possible development that would increase digital literacy competencies in schools. A professional jury selected a group of teachers from the pool of applicants, who were invited to develop further their submitted proposals for several months and to prepare the practical introduction of these methods. As part of this work, applicants had to blog their progress, present their results at road-shows, and besides their individual input they shared their experiences with other applicants.

The great success of the ICT workshop in 2008 triggered the ICT workshop in 2010, which was organised together with the annual Sulinet Camp. The programme included were the eTwinning professional development course on using Web 2.0 tools in educational settings. A publication containing video recordings of the ICT 2010 Workshop was made, enriched with lesson plans, technical aids and supplementary learning materials.

Sulinet portal

The Sulinet Portal (initiated in 1999) and the Sulinet Digital Knowledge Base[53] have been developed further, to integrate existing e-Learning systems and to introduce a new complex Sulinet e-Learning Portal based on Web 2.0 tools. The aim of this, which is the biggest Hungarian learning portal, is support of the use of ICT with both

[52] see *www.sulinet.hu/iktmuhely*
[53] at *sdt.sulinet.hu* accessible since 2004

Figure 6.16 ICT Workshop, Hungary

methodology and content. The new Sulinet portal and e-Learning system provides services for all stakeholders of the educational system: students, teachers, parents and other actors of the education industry. Within the unified framework, portal users can configure their profiles according to interests and aims. The renewed portal includes the Sulinet Digital Knowledge Base in a new form with extended content. The Sulinet Digital Knowledge Base continues to provide professionally moderated digital learning materials, which cover all subject areas in Hungarian K-12 education. The news portal at *www.sulinet.hu*, on the other hand, has become a magazine reporting on the whole state of the educational sector.

6.10 eTwinning

eTwinning is a community for schools involving more than 154,000 teachers across Europe. It is funded by the European Commission as part of the Lifelong Learning Programme of the Education, Culture and Audiovisual Executive Agency. European Schoolnet acts as the eTwinning Central Support Service.

The eTwinning network offers **opportunities for teachers** to meet and interact with each other in school projects, special interest groups and online forums. It also offers a rich professional development element via online learning events, focusing on collaboration skills and the use of technology with the goal of contributing to the **modernization of educational systems**, making them more attractive to today's youth[54].

The main concept is to facilitate pairing of schools within European countries on the choice of their topics so that they can work together using **Web 2.0 tools to share, build projects, improve communication skills, encourage cross-cultural exchange and intercultural awareness**. European Union member states, as well as Iceland, Norway and Turkey (supported by their own national support services) can participate by suggesting topics and searching for twin schools to work together on proposed topics, over time periods that could last from one week to many months or as a permanent twinning arrangement.

Several professional development workshops are organised in different countries every year aiming at new participants who want to learn more about eTwinning and to develop their ICT skills to promote European collaboration.

The eTwinning online network offers desktop, TwinSpace and other Web 2.0 tools for collaboration purposes, as well as training and exchange among teachers within groups on different themes, moderated by an experienced eTwinner. The aim is for eTwinners to share practice examples, discuss teaching and learning methodologies and find support for professional development.

The National Quality Label and the European Quality Label is granted each year to teachers with excellent eTwinning projects. They indicate that the project has reached a certain national and European standard.
The European Quality Label was launched in 2006. Since then it has been awarded to hundreds of European schools.

Publications on case studies, teachers' experiences and professional development, showcases of good practices and community building provide valuable readings for newcomers, and provide capacity building for improved cross-cultural exchanges of knowledge. The eTwinning newsletter is sent out by email once a month in 25 languages, thus indicating the robust multilingual dimension of this initiative, which is unprecedented in any other teaching and learning community network.

[54] find out more on *www.etwinning.net*

Noah's Ark: Slovakia - Malta, winning project from 2009/2010

Noah's Ark is a project about animals. Through its name we wanted to appreciate ecological values and ecosystem protection. Children 7 to 10 years old learned about domestic and wild animals in both countries. They collected information about them, and processed it in original ways. They jointly created common stories, a dictionary of words about animals, and shared presentations about animals, puzzles and crosswords. Most of all, they were learning about the other country and about the partner school and they were presenting about their own lives and neighbourhood. They were deeply engaged, creative and imaginative. In every activity they were using ICT with curiosity and enthusiasm.

Our goals in the project were: to use the famous Biblical story to inspire children to love animals and be responsible for them; encourage children to use English as their second language and motivate them to improve their language knowledge; develop their creativity and ICT literacy; give children opportunities to apply their individual skills; let them be tolerant and understand how people live in other countries; through novel forms of teaching motivate children to become active learners in all subjects; develop responsibility, cooperation, and solidarity among children (the Slovak children involved in the project were of two different age groups, and the older children were always highly supportive and helpful); teach children to express and present their thoughts and creations, to evaluate and assess work of other children and of oneself as well; develop positive attitudes in children for their country, their town and school.

Due to its topic and activities our project can easily be implemented by other schools. In our case it was embraced positively by everybody. Children from other classes wanted to experience the same innovative way of learning. They appreciated cooperating with peers from another country, and they liked using ICT. Even the parents got involved, helping their children identifying information, writing e-mails to their friends from Malta, encouraging their children in all activities.

Figure 6.17 Colouring book with numbers created by children involved in the project. "It was fun for us. We learned new names for the animals and practiced numbers and colours."

Tilgnerova Primary School, Bratislava, Slovakia and San Gorg Preca College, Hamrun GP Primary, Malta, see http://the-ark-of-noah-malta-slovakia.blogspot.com

6.11 Bebras: International Contest on Informatics and Computer Fluency

In Slovakia programming is considered a key component of *Informatics education* and a productive instrument for developing complex digital literacy. However, what is aimed for is creative, attractive, constructivist programming – not lessened by any misconceptions or bad practices, not reduced to *teaching a programming language*, or taught by a teacher who does not understand it. The aim is for programming or *computational thinking* competency as a powerful means for children to explore, model, control, communicate or express themselves. Teaching and learning strategies are being developed which should result in *programming for everybody* – **for boys and girls**, as a part of general education appropriate to contemporary creative society.

One of the strategies for promoting modern Informatics education, is to organize a range of contests for all student age groups. The most influential of these is the *Bebras*[55] or *iBobor* (in Slovak) contest, where i stands for Informatics.

iBeaver is an international contest for students of lower and upper secondary stages established in 2004 in Lithuania by V. Dagiene, see (Dagiene, 2010) for an overall picture. As illustrated by the diagrams below, the growing participation of countries and students is phenomenal and it reached 17 countries and 372,000 students in 2011. This validates the main goal of the contest, namely, to **promote interest in ICT and Informatics… to all children**.

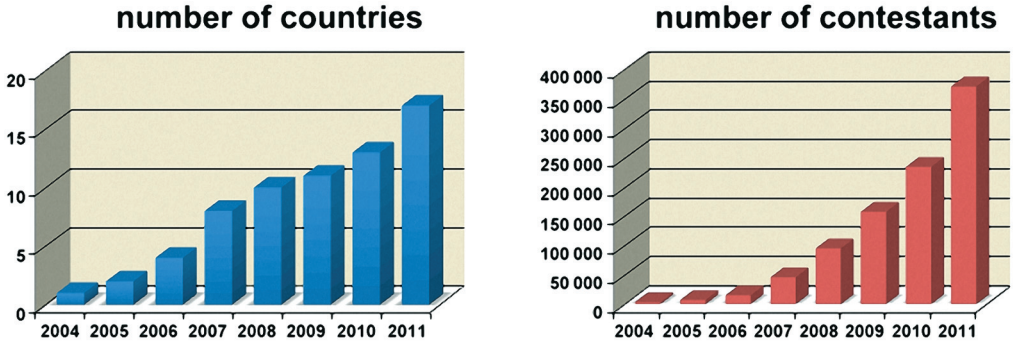


Figure 6.18 iBeaver competition: Participating countries and contestants

Slovakia joined iBeaver in 2007 and decided to run it as an online event. It attracts tens of thousands of children and beside all the other benefits it provides Informatics educators with an excellent opportunity to conduct educational research, see e.g. (Kalaš and Tomcsányiová, 2009). Since 2011 the scope of the contest was extended to challenge **primary children** between 8 and 10. The argument for this innovative move resulted from some earlier research findings: *At the age of primary and lower secondary stages there are no significant differences between boys and girls in their interest in modern Informatics education, neither is there any significant difference in their achievements – including programming. It is extremely important, though, to start at this age already and seek proper motivation and tasks that are attractive for girls as much as for boys.*

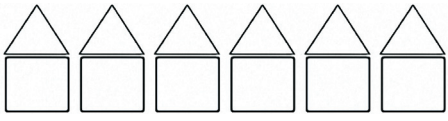
[55] see *http://bebras.eu* and *http://ibobor.sk*

Another strong argument in favour of the primary-age category for the iBeaver contest is the fact that since 2009 Slovakia belongs to that rare set of countries where *Elementary Informatics* is a compulsory and separate subject for every child from 7 years upwards. While ICT is being gradually integrated in all areas of learning, this new subject has its own distinctive learning goals – and its own problems with proper implementation, see (Blaho and Salanci, 2011).

Since there was little experience or research on Informatics contests for primary children, an enormous effort was made to prepare a pilot run with 7 727 children in 2011, see (Tomcsányiová and Tomcsányi, 2011).

To structure the contest properly the tasks for the children were categorized into four *components of Elementary Informatics education*: (a) **digital literacy** – basic concepts, computer literacy, security and legal issues, (b) **programming** – understanding, analyzing, interpreting and building descriptions of processes and behaviours, (c) **problem solving** – logical reasoning, strategies for problem solving, and (d) **data handling** – representations, patterns, data structures, data processing. Each task in the contest fits into one or two of these components. Following are two exemplary tasks for primary children.

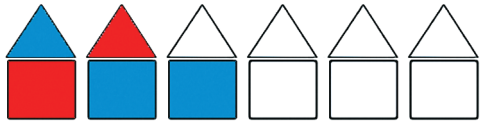
Use the Fill tool to colour the small houses in red and blue, both their triangle and square parts. Each house must have both parts painted. You can try it out by clicking the parts of the houses



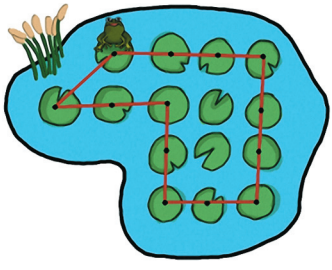
How many different houses can you make?

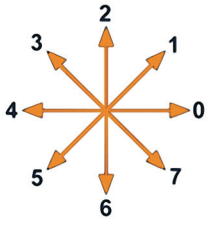
○ 3 ○ 5 ○ 2 ○ 4

Running the contest online gives a great opportunity to create **interactive tasks** (children can manipulate on-screen objects to construct the solution) and also multiple-choice **tasks with interactive helpers** (children can manipulate on-screen objects to help them understand the problem and discover its solution, then tick their choice).



Jane the Frog likes to jump from one water lily pad to another. First she turns towards the next lily – in one of eight possible directions (see the yellow compass), and then she jumps! She started





where you see her now and she is here back again. Which of these four scripts of directions records her journey shown by the red line?

○ 5, 0, 0, 6, 6, 6, 0, 0, 2, 2, 4, 4, 4
○ 0, 0, 0, 6, 6, 6, 4, 4, 2, 2, 4, 4, 1
○ 4, 4, 1, 0, 0, 0, 6, 6, 4, 4, 2, 2, 1
○ 0, 6, 6, 4, 4, 4, 2, 4, 1, 1, 1

6.12 A Week in the Life…, A Flat Classroom® Project

The concept of a flat classroom[56] is based on the **constructivist principle of a multi-modal learning environment** that is student-centered with a level "playing field" for teacher to student and student to teacher interaction. It is a pedagogy for collaborative learning which is also a series of projects. Two classroom teachers, Julie Lindsay (then in Dhaka, Bangladesh) and Vicki Davis (in Camilla, Georgia, USA) took the lead with the first project, and the initiative has grown from there into many collaborative projects uniting students and teachers around the world.

Defining the Global Collaborative Classroom: Flat Classroom

A classroom following **Flat Classroom** *project concepts is a classroom that connects and engages with multiple audiences, resources, and tools to create authentic, collaborative learning outcomes (Lindsay and Davis, 2012).*

The goal of all **Flat Classroom Projects** *is to create global collaborative projects and opportunities for students and educators around the world.*

By "flattening" the walls of the traditional classroom, participating classes essentially become one large virtual classroom, co-taught by participating teachers, via the Internet, using a combination of synchronous and asynchronous communication tools (Boss and Krauss, 2007).

The Flat Classroom Project is designed to develop cultural understanding, Web 2.0 and other digital skills, experience in global collaboration and online learning, and awareness of what it means to live and work in a world of globalization, while researching and discussing the ideas developed in Friedman's[57] core text (based on Peters, 2009).

The principles of these projects are always the same but the content varies:

- Common core content objectives between classrooms;
- Individual, personalized learning experiences for each student;
- The merging of classrooms from around the world for a period of collaboration and co-creation, with agreed outcomes;
- Innovative implementation and uses of multimedia, and students develop a wide variety of 21st century learning skills;
- Customizable activity components based upon the unique situation of each classroom's curricular objectives; and
- Empowered, engaged teachers with a commitment to build bridges that the society of tomorrow will walk across!

[56] see *www.flatclassroomproject.net*
[57] see (Friedman, 2007)

A Week in the Life…

"A Week in the Life…" (see the New Teacher Guide at *tinyurl.com/awlguide*) is a Flat Classroom Project for Elementary School students of ages 8-10. The curriculum focus is interdisciplinary: **how we live, how we communicate, cultural understanding** and **awareness**. The aim of the project is to join classrooms globally with a view to exploring what life is like in each country through discussion, sharing and collecting multimedia to co-create final products together. After forming an online learning network students are teamed in cross-school groups and given the task of deciding what media to collect and how to synthesize their ideas and responses to the questions to form their final multimedia response. This is then shared across all groups and classrooms for evaluation and feedback.

Essential questions for the students to consider:

- What are the similarities and differences among children around the world?
- How can we connect with each other through our what we have in common?
- How does your geography where you live impact your project topic?

Teachers in the project contribute to a blog to document progress and share their reflections and class activities. In the words of Nancy from Prague: *"The value of group work, within class and with global partners, was increased by the need to communicate in order to collaborate on a final project. For example, students learned to attentively read and appropriately respond to team members' comments and inquiries in the "Edmodo" chats. Learning that online communication is a productive means to work with others and share ideas, not just for daily chit-chat, was valuable as well"*. As von Wahlde says:

> *A relevant need to focus on the history of our host country arose, "We have different holidays, like in the USA you get a day off for Thanksgiving, not in Prague." When discussing why this was true, students became aware of the differing histories of various countries and they became more interested in the history of the Czech Republic.*
>
> *von Wahlde (2011)*

Figure 6.19 Young girl in front of a smart board talking to another class. St. Ignatius of Antioch School, Yardley, Pennsylvania USA, Teacher: Tina Schmidt

Digiteen Project

Another opportunity for students in upper elementary level to join together is the Digiteen Project. The focus is on **digital citizenship**, not just talking about it but experiencing it through involvement in a learning environment and joining with other students globally. The aim is to research areas of awareness and understanding for being a technology-aware citizen and user. Students co-author a wiki, discuss issues online, and finally design an action project to be implemented back in the home school.

Building Bridges to Tomorrow

This is a new project in the Flat Classroom collection that is being piloted for grades K-2. This project has brought together over 40 classrooms from more than 12 countries with a view to connecting, collaborating and enhancing students' global awareness while sharing simple concepts such as "celebrations", and "life on the way to school". The sub-text is to clearly show that students at this level can use Web 2.0 tools to get over the tyranny of distance and that they can solve problems while co-creating products together.

6.13 Personalisation by Pieces

In the UK, Cambridge Education has taken the six skills areas defined in the English national curriculum as Personal Learning and Thinking Skills (PLTS) and combined them with a skills framework from around the world to create the "Skills Ladder". Each of the 24 ladders provides nine steps of progression from beginner to professional. Each step is written in language accessible to learners working at that level so that students can actively engage in their own learning and progression. A student selects which one of the 24 skills he or she would like to develop. Figure 6.20 explains how a student selects **Independent enquirers** as her area of focus. The student selects **Evaluate evidence** as her skill ladder and chooses to work on a level 4 activity. The student collects and submits the evidence of works digitally. Students peer review each other's work.

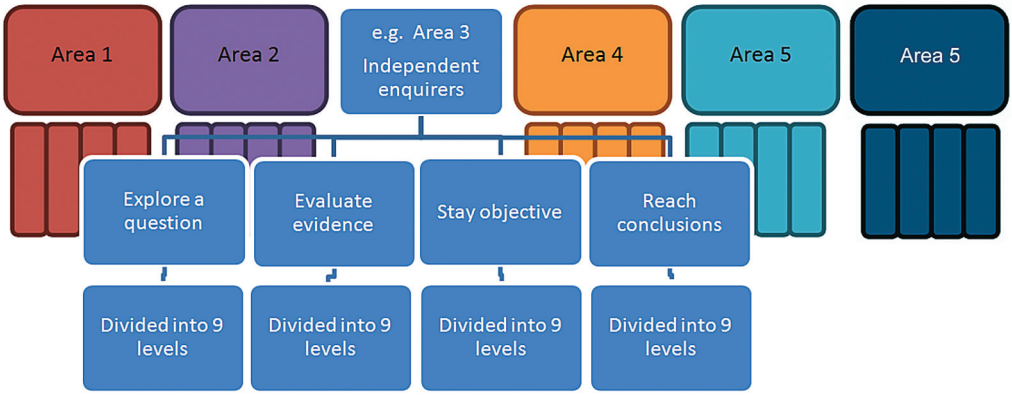


Figure 6.20 Each personal learning and thinking skill is divided into 9 levels

This approach is based on a philosophy called Personalisation by Pieces (PbyP) – a **unique model of collaboration** between children in different countries. Children become "experts" and then peer review each other's work. This provides a reliable and scalable way of recognising and rewarding children's **progress in skills such as creativity**. Schools from three continents are already using the website on a weekly basis. The following is a brief story from one of them that illustrates how the model works.

Callington Primary is a school of 355 children of ages 4 to 11 in South West England, which wanted to provide more personalised learning. In particular, they wanted to improve students' abilities to be more self-directed in their learning.

They heard about PbyP at a conference and bought software licences for all of their ten-year-old students to start. Two years later, they have now expanded this to all students of ages 7 to 11 as well as extending the "PbyP time" to two hours each week. The following notes are from an observation visit to the school:

> *In the early stages the children were not used to making decisions for themselves, they were used to teachers directing them and so they have had to develop those skills. Now they do this really well, the teachers explain, whilst two classes of children are working collaboratively on a whole range of different tasks all around them. In any one PbyP session there will be a group who brings costumes in from home to film a play to use as evidence, someone performing music, some building models and some using the computers.*

In our visit we saw a wide range of ICT equipment in use, from video cameras to voice recorders and PCs, all selected independently by the children to help them achieve the targets they had set themselves. Although all the children were working on their own targets, very few were working on their own. One of the children explained: *The target I set myself for this week was to help other people improve so I asked who needed help and I am working with (name) who had got stuck on his target and needed some ideas*. Another child explained how she wanted to improve her research skills: *I found two other people who were working on the same target so we decided to do something we were all interested in and share what we find out afterwards*.

> *You can get overloaded with targets but the PbyP skills targets are really nice because they (the children) make them their own. The teaching assistant added: The children really enjoy having the space and freedom to be creative. I think it is what they really need to make the learning exciting.*

How it works

PbyP contains a rubric for each essential skill. Each rubric has nine levels and is called a "Skill ladder". Each student logs in to their own personal set of skill ladders on a website and can work on any one of them in any order. The only rule is that they must pass level 1 before they can proceed to level 2 and so on up each ladder. In Callington the students have 24 skill ladders to choose from and these include such skills as "Imagination" and "Taking responsibility".

We asked three children to explain how PbyP works and have combined the answers they gave below (we added the numbers):

1. *First we choose a target to work on. I chose the "Get involved" ladder this week because my Mum has hurt her back and I thought I could do more to help.*
2. *When we have done the target we work out what evidence to upload to PbyP.*
3. *Your work goes to someone who has already passed the level in another school.*
4. *This piece I uploaded (points to tick on screen) went to a child in America. I could tell because when they wrote what they liked and gave me ideas to help me improve, the words were different.*
5. *If you pass you get a tick in your profile on that ladder, I have 18. This means you start getting work (to assess) from children who haven't passed that level yet.*
6. *Assessing evidence is fun but we have to do it carefully and be fair, we do that and we write a helpful comment.*

We would summarise the impact of using PbyP as reported by teachers and students as follows:

- Children have greater understanding of what happens in classrooms all over the world and "really enjoy assessing other children's work".
- The range of ICT devices in purposeful use increases.
- Children become more accurate at self and peer evaluation.
- Children take greater ownership of their targets.
- Children report getting better at expressing themselves through writing.
- Children's creative ideas begin to become more diverse and focussed.
- Children's ability to transfer skills between home and school increases.
- The status of essential skills increases in the school.
- Children who perform peer assessment value the responsibility and tend to reflect and evaluate more deeply.

Implementation at scale

As a web based solution PbyP scales easily: the more children, the more peer assessors. Small schools are no longer isolated as they have access to all of the student assessors and peer-rated work on the system. Callington teachers have linked up with a primary school in Australia using the same skill ladders, for example.

The PbyP model is very flexible so that it can be easily integrated into different contexts, recognising that there is considerable variation in existing practice and ethos from school to school. Once established its use tends to grow as self-directed work begins to gain status and teachers begin to add their own innovative ideas.

An excellent example of this local innovation happened at Callington, where they decided to provide every child with their own paper PbyP folder stored in the classroom. This allows children to write an action plan and tick off what they have done, as well as to remember their targets and to jot down ideas without having to find a computer. It is a perfect blend of old and new. They can also easily show off their PbyP certificates to visitors.

In conclusion, PbyP is a tool which works best when it becomes part of a weekly routine. Like office software, it is a tool to help you structure what you are doing without imposing limits. This new structure is supporting teachers as they slowly change the way they teach[58].

Unfortunately, most students who currently access the website are English-speaking and can therefore only assess each other's work in English. It is possible, though to create a database of examples and peer assessors in any language[59].

[58] find out more on *www.camb-ed.net/pbyp/*
[59] contact *pbyp@camb-ed.com* for information

6.14 Hole in the Wall, Self Organized Learning Environments

In 1999, Professor Sugata Mitra and his colleagues dug a hole in a wall bordering an urban slum in New Delhi, installed an Internet-connected PC, and left it there with a hidden camera filming the area. What they saw was kids from the slum playing around with the computer and in the process learning how to use it and how to go online, and then teaching each other[60].

This experiment showed that groups of children, given shared digital resources can learn to use computers and the Internet to **learn almost anything on their own that they have an interest in**. They do not seem to require adult supervision.

Figure 6.21 Children interacting with a PC via a hole in the wall, see www.bbc.co.uk/news/technology-10663353

Further work showed that groups of children with access to computers and related technology are capable of successfully answering examinations without traditional schooling.

Towards a new Education

Since successfully completing school is such a widespread concern, the project took on the task of studying whether such **self-organized learning** can enable groups of children to successfully answer government Board final examinations and be helped to obtain their school certificates using such "Minimally Invasive" methods.

Groups of children (6-12 years old in groups of 4 or so), given unrestricted and unsupervised access to the Internet can learn a lot on their own. It doesn't matter who or where they are. This is known from 20 years of research, standing on the shoulders of Aurobindo, Piaget, Vygotsky and Montessori. This kind of learning is activated by the learner's own questions, not from being told.

Hypothesis

There will always be people in the world who are willing to mediate in children's learning for, say, one hour a week, with no remuneration. Therefore if "clouds" of mediators and children on the Internet may be organised and an arrangement by which they can interact, a form of alternative schooling is created.

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[60] see more at *www.ted.com/speakers/sugata_mitra.html*

Action

In the last three years, 12 Self Organized Learning Environments (SOLEs) were created in addition to the several hundred "hole in the wall" computers that exist in India, Cambodia, Columbia and several African countries[61].

Furthermore a cloud of mediators was created and they have begun to interact with these SOLEs. The cloud is self organized and called a Self Organized Mediation Environment (SOME). The mediators interact with the children using Skype.

The SOLE Facility

Typically, a SOLE is a "room" located in (up to now) school premises, and clearly visible to all those who pass. The rooms normally have large glass windows for increased visibility and transparency to ensure children's safety, as well as unobtrusive monitoring of the activities inside the SOLE.

There are usually 9 computers in clusters of 3, which facilitate the children's interaction across computer terminals as well within each group using one computer. A key factor is that there are usually 4 children per computer working or playing together, many more children are often gathered behind, standing around watching what's going on. The key in all this is *open and free access*. Of course there are many hiccups along the way. In most places there are many children, and little time, just one "room" and some resistance to the idea! But the response of the children and many of the schools and teachers has been insightful and heartening. New discoveries are made and shared everyday, skills practiced and mastered, confidence and self worth levels are rising; all this is evident to the observer of these groups.

Figure 6.22 The Hole in the Wall experiment has been repeated in many different places[62] , (see www.bbc.co.uk/news/technology-10663353)

One of the key concerns for many parents, educators, and even the children themselves, has to do with learning English. So, from the beginning, specific software was installed for children to be able to learn the English language, and to use it on a regular basis.

Although the hypothesis is that children do not seem to need adult supervision, however, this does not mean that they do not need "benign mentors". It seems, from the response to the research done, that there is a very large number of people in the world who are willing to give a little of their time to be mentors for children who need it.

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[61] see *solesandsomes.wikispaces.com*

[62] In Chapter 2 however we pointed out that some of the claims of the advocates of these experiments have been the subject of critical reactions as well, see e.g. (Arora, 2010)

6.15 iEARN, International Education and Resource Network

iEARN is a non-profit network that supports over 40,000 teachers and 2 million young people in more than 130 countries and more than 30 languages to collaborate through a global online network, in projects designed to make a difference in the world. Since 1988, iEARN has pioneered the use of interactive technologies to enable students to engage in meaningful educational projects – with peers around the corner and throughout the world.

iEARN is:

- a safe and structured environment in which young people can communicate,
- a community of teachers and learners,
- a known audience for writing and reading with a purpose,
- an opportunity to apply knowledge in service-learning projects,
- an inclusive and culturally diverse community.

After joining, teachers and students enter an online Collaboration Centre to meet other participants and get involved in ongoing projects, initiated by peers throughout the world. In addition to meeting a specific curriculum or subject area need, every project proposed in iEARN has to answer the question: *How will this project improve the quality of life on the planet?* That purpose is the glue that holds iEARN together. Through participation in iEARN projects, students develop the habit of working collaboratively with their counterparts locally and globally, and come to understand the positive role they can play in their communities.

iEARN offers both face-to-face and online professional development workshops for educators interested in integrating global project work and online collaboration tools into their classrooms. iEARN facilitators work closely with participating schools and teachers to design training that meets their needs and interests. After attending an iEARN workshop, participants return to their schools with a built-in support network – ongoing technical and staff development assistance from iEARN staff, as well as an online community of colleagues worldwide[63].

Daffodils and Tulips

In this iEARN project classrooms around the world choose Daffodil or Tulip bulbs to plant. Students are asked to collect data on various parameters (latitude, longitude, sunlight, temperature etc.). In addition, they report when the blooms appear. Students have opportunities to practice math skills, science skills, and appreciate geography and culture while sharing with classrooms across continents. The project can be as involved or as simple as a class needs it to be and is suitable for students from any age. Contact persons: Ruty Hotzen at eh2y@netvision.net.il or Amy Dwyer at ewmstech@elementaryworkshop.org.

[63] For the most accurate listing of iEARN projects see *media.iearn.org/projects*

6.16 Concluding points

The list of projects or initiatives we selected for this chapter is by no means exhausted exhaustive – there are thousands more available to learners, teachers and school leaders. We believe that the examples presented show the potential of using ICT to enhance the different dimensions of teaching and learning.

Some examples focused more directly on professional teacher development. We know that teachers play a fundamental role in changing classroom practice. Primary school teachers can improve and update their pedagogy to allow all learners to reach their full potential through the creative and innovative use of ICT. Strategies for professional primary teacher development will be the subject of the third volume of this study.

7 Conclusion

The goals of our project were set as *analyzing different approaches, priorities, obstacles and strategies, and articulating recommendations for integrating ICT into the everyday work and play of primary children and their teachers*. Intentionally we decided not to address the question *Why use ICT*, and particularly *Why use ICT in the primary school*, although this used to be a critical question frequently asked by teachers, parents and education policy makers 15 or even only 10 years ago. When Leask and Meadows in (2000) studied that question, they summarized the following clusters of reasons why primary schools **need to use ICT**[64] :

1. The communication aspects and the ways in which a constructivist theory of education can be supported through ICT.
2. The skills which children gain by being able to control ICT applications.
3. The confidence children gain by communicating through and controlling their environment.
4. The needs for communication skills in their future careers, both in school and in the workplace.
5. Access to information on the Internet, although this is still a problem, since much of the content is in an adult form.
6. The creative power of ICT, especially in the making of web pages, using text and graphics, as well as more advanced facilities.
7. Communication technologies, such as audio and video conferencing, enabling children to communicate their ideas across national and local boundaries.

Today, we know that our lives in the 21st century – our playing, learning, developing and living – are being shaped by many factors, all permeated by digital technologies. Trilling and Fadel (2009) describe four powerful forces converging and leading us towards new ways of learning for life in the 21st century: **knowledge work, thinking skills, digital lifestyles,** and **learning research**[65].

We took this belief as a premise for our analytical study. First of all, we keenly accepted recent research findings which confirmed that primary education is the most formative period – together with the pre-primary stage – for any child's personality, productive learning processes, and skills for learning and metacognitive competencies. Primary education is also exceptional because in many countries most subjects at this level are taught by the same teacher. This fact and several others create a brilliant opportunity to integrate digital technologies into subject teaching, into cross-curricular activities and into 21st century skills development. Primary education is a playful realm in which teachers know very well that learning without play and positive motivation does not happen. Primary teachers are usually highly innovative and know that they have to learn and develop themselves continuously, for example, that they have to develop their own digital literacy, because only a digitally literate teacher can harness these powerful forces towards new ways of learning.

The outcome of our project will be a series of reports, the first of which is this one. In this report we decided to explore the roots and premises of the views that have pointed out the potential of digital technologies to support changes in primary teaching and to enhance new and different learning

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[64] It is an inspiring and useful exercise to carefully analyse similar lists of arguments from ten or more years ago and ponder on which of the arguments are still actual and why, and which arguments should be removed and/or replaced by other issues.

[65] we characterized these in detail in Chapter 1, in the section *This is the digital generation*

processes of our pupils; we presented a research literature review on the opportunities, limitations and concerns associated with ICT in teaching and learning processes in primary schools; we identified several principles that are common to most of the national strategies for ICT in education; and we introduced a rich collection of different national and international initiatives, networks, and projects that have been or are being successfully implemented and could be of value for the reader.

Integral to our study is a collaboration with a sample of exceptionally innovative primary schools around the world. In this volume we briefly introduced the first nine of these schools, and asked them to provide us with inspiring visual material to illustrate the chapters of this report. Currently we are extending our initial sample up to several dozen inventive primary schools from different countries – representing various cultures, traditions, approaches, and platforms for innovation. In extensive communication with them we will obtain inspiring and representative data for qualitative research about how ICT is reshaping the teaching and learning processes of children in primary education. The analysis of that data will give us excellent opportunity to focus on the most important factors for ICT in primary education, including the various manifestations of transitions in teaching and learning processes, the organization and forms of activities enhanced by digital technologies, the management process, teachers' professional development, the different categories of ICT deployed in learning process, and many more issues. We will also collect and present in later publications a rich spectrum of the best practices from the different cultural and socioeconomic backgrounds of our sample schools.

In the final volume of our study we will concentrate on formulating standards and recommendations for the process of integrating ICT into teaching and learning processes in primary education, strategies and outlines for professional primary teacher development programmes, reflections on future developments and other related issues. We still have a long, exciting and challenging journey in front of us.

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Appendix 1: National documents summaries and highlights

This section summarises the key points from a selection of national strategy documents on ICT in primary education, in terms of: the agencies involved; notable initiatives; curriculum plans; tools, resources and services to be made available to schools; and policy on teacher development.

Australia: Summary and Highlights

Agencies involved

The Council of Australian Governments.

Initiatives to promote change

Collaborative content creation supported by Commonwealth, state and territory funds.

Curriculum

The focus is on flexibility; decentralised and highly collaborative approaches to development; strong coordination, highly consultative processes.

Tools, resources and services

The strategy is to support ICT infrastructure as learning systems including learning management systems, e-portfolios, collaboration and communication spaces; digital education resources.

Teacher development

Planning and teacher professional development; a focus on leadership

School system capability benchmarking and professional development programs; Knowledge building and sharing systems for teachers; School sector leadership development programs.

Source: http://www.deewr.gov.au/Schooling/Pages/default.aspx

Eritrea: Summary and Highlights

Agencies involved

Ministry of Education's ICT Unit, National ICT Steering Committee, Regional ICT Units; Departments of Research and Human Resource Development, of Adult and Media Education, and of Technical Education and Vocational Training.

Initiatives to promote change

A public awareness programme to raise awareness of the value of ICT in education; equitable opportunities for students in kindergarten and primary to access and utilize ICT tools; performance-based assessment to include student portfolios, project-based learning, and authentic learning relevant to real-world work.

Curriculum

The national curriculum will facilitate knowledge, skills, attitudes and actions for an information literate society; a more student-centered, outcome-based approach; ICT as a teaching and learning tool, and alternative assessment strategies.

Tools, resources and services

The Ministry is responsible for a multimedia R&D centre to design and produce multimedia materials for educational purposes, and for all forms of hardware and communications provision.

Teacher development

Pre-service teacher training and in-service programs will implement basic ICT literacy and pedagogical training for integration of ICT in teaching and learning, and in the theory and practice of technology integration in teaching and learning.

Source: blogs.worldbank.org/edutech/

France: Summary and Highlights

Agencies involved

National: Department of Information and Communication Technology in Education. Regional structures of the Ministry are responsible for implementing national directives and policies.

Initiatives

Hardware and software for rural schools; e-books; VLEs encouraged; quality stamp for multimedia resources.

Curriculum

ICT is not taught as a separate subject. It is embedded in all subjects, at both primary and secondary levels.

Tools, resources and services

The PrimTICE portal offers pedagogical scenarios for primary education. Agreements with publishers to license the development of commercial products. The MoE has designed the "RIP" label for the quality of educational ICT resources.

Teacher development

ICT initial training is provided by regional IUFM (Academic Institute for Teacher Training). The "Pairform@nce scheme" is based on the collaborative production of teaching sequences and activities using a variety of resources and is implemented via a national working platform for primary and secondary education.

Source: insight.eun.org

Hong Kong: Summary and Highlights

Agencies involved

Education Bureau, Centres of Excellence (schools successful in integrating ICT).

Initiatives to promote change

Develop a model school-based IT in education roadmap for schools' reference; workshops for schools on how to develop and implement the roadmap.

Curriculum

Develop teaching modules on Chinese, English, Mathematics and Science (and General Studies in primary schools) for primary 1 to secondary 3 levels. Integrate ICT into lesson plans using digital resources, tools for student activities, and online group collaborative work.

Tools, resources and services

A public education portal for IT in education, providing curriculum-based teaching modules with appropriate digital resources; commission other organizations to develop resources that empower parents in using ICT for learning at home.

Teacher development

Develop teacher capacity building programmes focusing on the use of IT for student-centred learning activities, with overseas scholars, and expand the existing dissemination mechanism of good IT pedagogical practices among teachers.

Source: www.edb.gov.hk

India: Summary and Highlights

Agencies involved

National and State Councils of Educational Research and Training, Central Institute of Educational Technology, National Institute of Open Schooling, and State Institutes of Educational Technology.

Initiatives

Extend ICT literacy to Upper Primary stage; a nationwide School Education Management Information Systems network will be established for schools, teachers, students, school managers, and the community, to include tools, content and resources.

Curriculum

National and State agencies will develop curriculum and resources to serve as models across the system. States will develop an ICT literacy curriculum and course materials in the form of self-instructional materials, to develop a broad set of generic skills.

Tools, resources and services

Equip every school with broadband connectivity and a computer lab aiming for a 10:1 pupil-computer ratio. Open access digital resources for all schools; ICT tools for digital skills and specialised software for different subjects, simulations, virtual labs, modelling and problem solving applications will be encouraged.

Teacher development

Induction training will be introduced and refresher training should be carried out every year to enable teachers and leaders to share, learn and keep abreast of the latest trends in ICT-based teaching and learning processes.

Source: www.unescobkk.org/education/ict/

Kenya: Summary and Highlights

Agencies involved

Ministry of Education, Science and Technology and Ministry of Information; Ministerial ICT Committee, the Semi-Autonomous Government Agencies, and the Network Initiative for Computers in Education (NICE).

Initiatives to promote change

Planning for public/private development partner collaboration for effective sector-wide ICT initiatives; e-education networks for sharing educational resources; ICT training for leaders; help for the disadvantaged to acquire ICT skills; R&D in ICT.

Curriculum

ICT is seen as a tool for curriculum delivery and learning, integrating ICT in teaching curriculum at all levels of education.

Tools, resources and services

Connecting remote education institutions through the Internet via the National Educational Portal; special hardware and software for special needs; improved access to local ICT facilities; to customize or develop educational software to meet local needs.

Teacher development

The nation's 197,000 primary school teachers and 38,000 secondary school teachers will be trained in ICT literacy and integration, with the aim to build the capacity of at least one teacher in each school to teach ICT, support ICT literacy and integration and basic maintenance of ICT equipment.

Source: blogs.worldbank.org/edutech/

Norway: Summary and Highlights

Agencies involved

Ministry of Education and Research; Norwegian Centre for ICT in Education.

Initiatives

Computer-based exams are an option for the final examination after year 10; some use of ICT has been obligatory, including spreadsheets and the Internet. Digital exams are likely to replace paper ones within a few years.

Curriculum

ICT should be an integrated part of learning activities among all students, at all levels of primary and secondary education and in all subjects. There are specific educational uses of ICT in different subjects, and learning goals for digital literacy.

Tools, resources and services

The ITU Mentor service will help schools improve their "e-maturity", and achieve better standards in ICT; the national education portal for primary provides digital content for schools.

Teacher development

Pedagogy and pupil-related skills has been introduced as a new, expanded educational science subject. A curriculum framework is being developed for initial teacher training in ICT across the curriculum. It is compulsory for teachers of all subjects and levels to integrate ICT in their teaching; there is no compulsory in-service training.

Source: insight.eun.org

Qatar: Summary and Highlights

Agencies involved

Supreme Education Council (SEC), ictQATAR.

Initiatives

ictQATAR's e-maturity diagnostic and self assessment tool measures how ICT is integrated and adopted in each school; making digital content available for educational purposes.

Curriculum

Teachers collaborate with each other and improve the delivery of education by making it more engaging and interactive. Education tools can be customized for each student and adapted based on their skill levels and intellectual interests.

Tools, resources and services

SEC is developing curriculum-based digital content for K–12; creating a national e-library that includes digitized books and other learning resources.

Teacher development

ICT training and professional development for educators; and increased usage of the National Government Network to enhance information sharing between schools; 71 percent of K–12 school teachers receiving ICT training.

Source: www.ictqatar.qa/en/documents

Russia: Summary and Highlights

Agencies involved

National Training Foundation; Ministry of Education.

Initiatives

The information and education environment of primary school will include digital tools, and the qualification of teachers and leaders will include solving learning, cognitive and professional tasks with ICT: integration of ICT in all subjects of primary education and the development of meta-cognitive skills with the inherent use of ICT.

Curriculum

Cross-curriculum work in the primary school should reflect the use of ICT for communicative and cognitive tasks. Students develop skills to work in information environments as required for the content of particular disciplines.

Tools, resources and services

Tools and resources will be provided to support teachers in creation and use of information, information retrieval, digital data analysis, modelling, etc. Broadband connectivity for all schools.

Teacher development

Provision of remote interaction and the opportunity to use data accumulated in the education process for learning management; interaction between schools, education authorities, and other institutions of education and organizations.

Sources: http://www.ed.gov.ru/edusupp/informedu and http://rpio.ru

Singapore: Summary and Highlights

Agencies involved

Ministry of Education, National Institute of Education, Infocomm Development Authority of Singapore.

Initiatives

MoE will establish a network of educational laboratories for innovations, with educational technologists, curriculum specialists from the Ministry, experts and teachers, the laboratories acting also as training grounds for both “specialist teachers” and all student teachers.

Curriculum

Integrate ICT during the planning and design of lessons and the daily curriculum in schools. Work through implementation details of curriculum and assessment; interactive environments provide more opportunities for practice.

Tools, resources and services

Increase the network bandwidth for schools so that they can engage in anywhere, anytime learning; put computing power in the hands of every learner, be it a low-cost laptop or a digital PDA for every child to enable mobile learning.

Teacher development

Continue to upgrade the capabilities of all teachers; develop a cadre of teachers with strong pedagogical grounding as "specialist teachers" in schools to lead effective integration and infusion of ICT into the classroom and the curriculum.

Source: www.moe.gov.sg/media/speeches

USA: Summary and Highlights

Agencies involved

Department for Education, National Science Foundation; school districts, state education agencies.

Initiatives

Focus education research on "grand challenge problems"; organise learning around demonstration of competencies; use technology-powered programmes from primary grades to college level; use assessment data to drive improvement.

Curriculum

A core set of standards-based concepts and 21st century competencies, including ICT, should be woven into all topic areas. Technology will provide access to learning resources beyond the classroom to connect to parents and mentors as well as teachers.

Tools, resources and services

Provide an always-on platform with access to an online learning community and ICT resources; develop learning resources that use technology to model design principles from the learning sciences.

Teacher development

Give teachers access to technology-based content, resources and tools; create communities of practice for teachers; use technology to give teachers professional learning experiences and digital literacy skills.

Source: www.ed.gov/about/offices/list/opepd/ppss/reports.html

UK (England and Wales): Summary and Highlights

Agencies involved

Department for Education (and also the former agency Becta, until 2010).

Initiatives

Previous projects included: Home Access: targeting the most disadvantaged families to provide access to appropriate technology to support learning at home for over 200,000 children; E-safety: to ensure that every young person develops the skills to use technology effectively and responsibly.

Curriculum

ICT is a defined subject in the national curriculum, and seen as a skill to be applied in most other subjects. Becta produced a set of documents that exemplify a pupil's entitlement to use ICT, across the curriculum for primary and secondary subjects.

Tools, resources and services

The UK is served by a large and active software and content industry. A framework agreement defines the conditions suppliers must meet for software purchases by schools.

Teacher development

It is recognized that ICT skills are an essential part of the professional standards for teachers. ICT is fully integrated into initial teacher training, through both undergraduate and postgraduate levels, and is specifically included in three of the compulsory standards for qualified teacher status.

Source: insight.eun.org