What Is Happening with ICT-based Innovation in Educational Systems?

Overview of Educational Visions, Concepts and Developments for 21st Century Education

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1 Introduction

> *Do not then train youths to learning by force and harshness, but direct them to it by what amuses their minds so that you may be better able to discover with accuracy the peculiar bent of the genius of each (Plato)*

The advent of computers and particularly networked computing enabled by potentially all-pervasive networks such as the Internet have stimulated the rise of powerful visions, concepts and efforts for the world of the 21st century. Humanity has entered a massive innovating-learning process which, not-surprisingly, is placing educational systems at the core, both as object and agent of change. Scholars such as Levy (1997) have cogently sought to depict the enormous impact of ICTs on society and particularly education. Thus,

> … il cyberspazio … costituirà ben presto il principale dispositivo collettivo internazionale della memoria, del pensiero e della comunicazione. Insomma, tra qualche decina d'anni *il cyberspazio … sarà il medium essenziale dell'intelligenza collettiva dell'umanità*.
> Con questo nuovo supporto d'informazione e comunicazione emergono generi di conoscenza inauditi, criteri di valutazione e orientamento del sapere inediti, nuovi soggetti attivi nella produzione e nel trattamento delle conoscenze. Ogni politica educativa dovrà tenerne conto.[1]

The previous section has shown that, in the US and Europe, this process is well under way stimulated by a combination of policy processes and innovation initiatives taken by schools and teachers themselves. On the whole however the transformation of the educational system to exploit the full potential of cyberspace is still in its infancy. Suffice to think in terms of potential benefits as "mass customization" or "personalized learning' and the possibility to enrich the effectiveness and motivational appeal of constructivist, ludic, and collaborative learning approaches, among other aspects. This paper looks at these new concepts and developments in relation with ICT-based innovation.

2 The Changing Role of the Teacher: from "Provider" to "Facilitator"

In the words of Levy (1997), 'cooperative learning' and the transformation of the teacher into an animator of the "collective intelligence" –rather than a transmitter of knowledge- is one of the most promising benefits in the qualitative change brought about by the use of ICTs. Thus,

> … il punto essenziale, qui, è il cambiamento *qualitativo* del processo di apprendimento. La direzione più promettente, che d'altronde traduce la prospettiva dell'intelligenza collettiva in campo educativo, è quella dell'*apprendimento cooperativo*. … Nei nuovi 'campus virtuali' I professori e gli studenti mettono in comune le risorse materiali e informativi di cui dispongono.
> A questo punto la funzione principale dell'insegnante non potrà più essere la diffusione di conoscenze, ormai assicurata più efficacemente da altri mezzi.
> La sua competenza deve spostarsi e trasformarsi in una provocazione all'apprendimento e al pensiero. L'insegnante diventa l'animatore dell'intelligenza collettiva dei gruppi di cui é responsabile. La sua attività sarà incentrata sull'assistenza e la gestione degli apprendimenti. L'incitamento allo scambio dei saperi, la mediazione relazionale e simbolica, la guida personalizzata ai percorsi di apprendimento, ecc.

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[1] Levy, P., *Cyberculture*, O. Jacob, Paris 1997. Also, Levy, P., *Collective Intelligence: Mankind's Emerging World in Cyberspace*, Plenum Press, NY, 1997.

The same concept is stressed by Batini and Fontana (1997)

> La nostra didattica tradizionale, in quanto scienza dell'insegnamento, é sempre stata centrata sull'oggetto postulando la necessità di *trasmettere* un sapere, semplificando, si é più volte sintetizzato come il passaggio di 'qualcosa' da un contenitore pieno ad uno vuoto;
> … il formatore modifica la sua prassi formativa e diventa un facilitatore, o meglio un *mediatore* nel campo comune della conoscenza costruita/narrata tra docente e dicente stessi.[2]

Haddad and Draxler (2002) provides a more dynamic view of this teachers' transformation from "transmitter" to "mediator," or, as they prefer to call it from "provider" to "facilitator." Figure 1 illustrates the increase in the number of didactic activities and skills that takes place as the teacher's and the learner's roles evolve from "provider" to "facilitator" and from "passive" to "active" respectively. The traditional teacher and learner didactic relationship is found at the bottom-left side of the diagram in the form of a "provider-passive" relationship dominated by a didactics of 'presentation." As the relationship moves increasingly towards one of "provider – facilitator," the didactic activities and skills become more and more interactive until they reach the status of "collaborative," in which teacher and learner are both important contributors to the learning process.

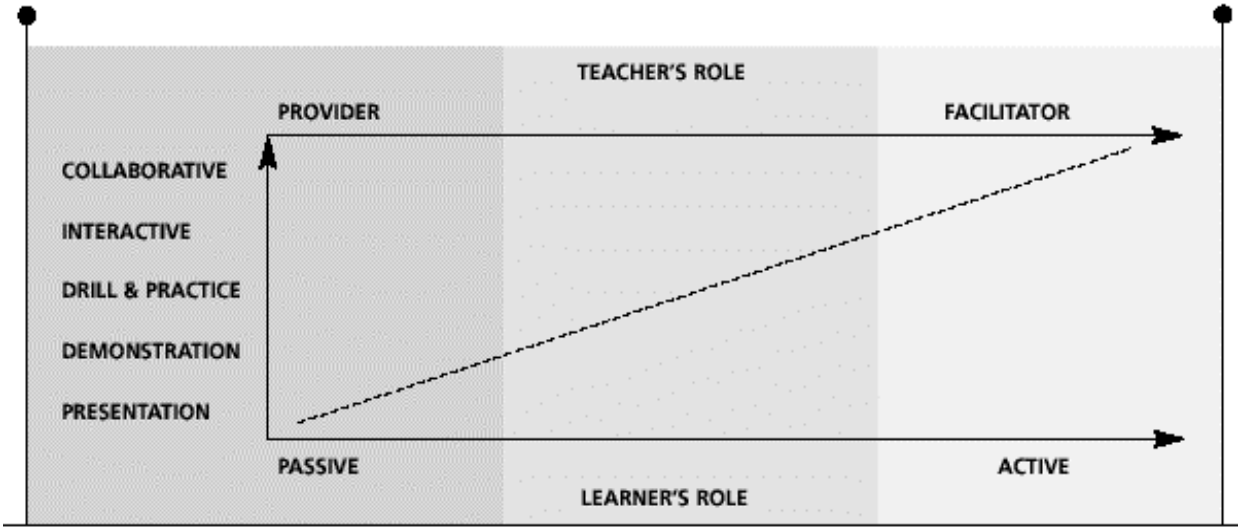

Figure 1. Use of ICTs for different Roles of Teachers and Learners

Source. Haddad, W. and Draxler , "The Dynamics of Technology for Education" in Haddad, W. and Draxler, A. (eds), *Technologies for Education: Potentials, Parameters and Prospects*, UNESCO and AED, Paris and Washington, 2002. pp..2-17, Figure in p.13.

The ultimate direction of this teacher-learner transformation towards "collaboration" implies changes in many of the concepts and practices characterizing learning processes in most of today's schools. Indeed, it is crucial to take a holistic approach and recognize that the real challenge is the emergence of completely new "physical/virtual learning communities and environments," in which achievement and lifelong learning goes hand in hand with the motivation, commitment, and passion for learning that results from high quality working and learning conditions and resources for students, teachers, and all relevant educational personnel. In this view, intra- and inter-schools "learning communities" will tend to operate at multiple levels, very much as combinations and and re-combinations of "communities of practice" in the sense of Wenger[3] or as "sociotechnical constituencies" in the sense of Molina - as we shall see below.[4]

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[2] Batini, F. and Fontana, A., *Comunità di Apprendimento*, 1997.

[3] Wenger, E., *Communities of Practice: Learning, Meaning, and Identity*, Cambridge University Press, Cambridge, 1998. (Harvard Business School Press, 2002).
Wenger, E., *Cultivating Communities of Practice,* Also, Wenger, E., McDermott, R., and Snyder, M., *Cultivating*

Table 1 lists some of the main features of these "communities of practice." It is possible to see the emphasis on: development of individual capacities, self-selection, passion and commitment, and relevance. Of course, in education there will be a degree of common curricular content to be completed – and this will be normal part of the overall governance of the "learning communities." Beyond this however the forms, sizes, dynamics, instruments, duration, etc. of the learning communities as can be infinite and open to constant improvement within the "physical/virtual learning environments."

Table 1. Features of Communities of Practice	
What's the purpose?	To create, expand, and exchange knowledge, and to develop individual capabilities
Who belongs?	Self-selection based on expertise or passion for a topic
How clear are the boundaries?	Fuzzy
What holds them together?	Passion, commitment, and identification with the group and its expertise
How long do they last?	Evolve and end organically - ast as long as there is relevance to the topic and value and value and interest in learning together

Source. Wenger, E., McDermott, R., and Snyder, M., *Cultivating Communities of Practice: A Guide to Managing Knowledge*, Harvard Business School Publishing, 2002

3 The Rise of "Community-Individual" Dialectics in Learning Processes

The co-operative, community aspect of the new "physical/virtual learning communities and environments" is only part of the educational gain promised by ICT-based innovation in the educational system. The other aspect highlights the importance of the *individual learner* and, particularly, the systematic "personalization of learning processes" to suit the characteristics or personal profile of the individual learner. In this respect, "community" and "individual" (as member of communities) are fully integrated in new inter- and intra-school environments that make possible "mass-customization" of education. Ultimately, this system should facilitate the community to be a learning resource for the individual learner and, conversely, the individual learner to be a resource for the learning community.

Gardner's concept of "multiple intelligences" [5] is useful to highlight the strategic importance of reaching "personalized" learning within systematically orchestrated "community-individual

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Communities of Practice: A Guide to Managing Knowledge, Harvard Business School Publishing, 2002

[4] See Molina, A., The Role of the Technical in Innovation and Technology Development: The Perspective of Sociotechnical Constituencies, *Technovation*, Vol.19, 1999, pp.1-29. Molina, A., Transforming Visionary Products into Realities: Constituency-Building and Observacting in the Case of NewsPad. *Futures*, Vol.30, No.9, April 1999. Molina, A., Insights into the Nature of Technology Diffusion and Implementation: The Perspective of Sociotechnical Alignment, *Technovation*, 1997, Vol.17, Nos.11/12, pp.601-626. Molina, A., Sociotechnical Constituencies as Processes of Alignment: The Rise of a Large-Scale European Information Technology Initiative, *Technology in Society*, Vol.17, No.4, 1995, pp.385-412. Molina, A. In search of insights into the generation of techno-economic trends: Micro- and macro-constituencies in the microprocessor industry, *Research Policy*, Vol.22, Nos.5/6, 1993, pp.479-506. Molina, A. Transputers and transputer-based parallel computers: Sociotechnical constituencies and the build up of British-European capabilities in information technology, *Research Policy*, No.19, 1990, pp.309-333.

[5] See Gardner, H., *Frames of Mind: The Theory of Multiple Intelligences*, Basic Books, NY, 1983. Gardner, H., *Intelligence Reframed: Multiple Intelligences for the 21st Century*, Basic Books, NY, 1999. And Gardner, H., *Multiple Intelligences: The Theory in Practice*, Basic Books, NY, 1993. Gardner, H. and Hatch, T., Multiple Intelligences Go To School: Educational Implications of the Theory of Multiple Intelligences, *CTE Technical Report Issue No. 4*, March 1990, found in http://www.edc.org/CCT/ccthome/reports/tr4.html .
See also, Nelson, K., *Developing Students' Multiple Intelligences (Grades K-8)*, Scholastic, Jan. 1999. Schmidt, L., *Seven Times Smarter: 50 Activities, Games, and Projects to Develop the Seven Intelligences of Your Child*, Three Rivers Press, 2001. Silver, H., Strong, R., Perini, M., *So Each May Learn: Integrating Learning Styles and Multiple Intelligences*, Association for Supervision & Curriculum Development, Nov. 2000. Teacher Created Materials Inc., *The Best of Multiple Intelligences Activities*, Feb. 1999. Campbell, L., Variations on a Theme: How Teachers Interpret MI

dialectics of lifelong learning" (i.e., defined, specified, implemented, monitored, evaluated and constantly enriched processes in which the individual and the community are essential to each other learning development). In particular, the concept of "multiples intelligence" highlights four visible facts:

- Learning has multiple elements (e.g., knowledge, information, skills) and dimensions (e.g., linguistic, logical, musical, communication)
- Learning involves a range of human capacities, abilities, sensitivities and propensities (e.g., linguistic, logical, musical, communication)
- Different dimensions of learning involve different human capacities, abilities, sensitivities and propensities (e.g., linguistic, logical, musical, communications)
- Individuals show differential combinations of capacities, abilities, sensitivities and propensities for learning.

Gardner (1983, 1987) calls "multiple intelligences" the different learning capacities, abilities, sensitivities and propensities, and his work has distinguished the existence of nine "intelligences." These are reproduced in Table 2 while Figure 1 provides a useful pictorial representation. The first seven Gardner distinguished in his 1983 book *Frames of Mind* and the last two in his 1999 book *Intelligence Reframed*.

Table 2. Multiple Intelligences

Verbal-Linguistic	Well-developed verbal skills and sensitivity to the sounds, meanings and rhythms of words
Mathematical-Logical	Ability to think conceptually and abstractly, and capacity to discern logical or numerical patterns
Musical	Ability to produce and appreciate rhythm, pitch and timber
Visual-Spatial	Capacity to think in images and pictures, to visualize accurately and abstractly
Bodily-Kinesthetic	Ability to control one's body movements and to handle objects skill fully
Interpersonal	Capacity to detect and respond appropriately to the moods, motivations and desires of others.
Intrapersonal	Capacity to be self-aware and in tune with inner feelings, values, beliefs and thinking processes
Naturalist	Ability to recognize and categorize plants, animals and other objects in nature
Existential	Sensitivity and capacity to tackle deep questions about human existence, such as the meaning of life, why do we die, and how did we get here.

Source. Gardner, H., *Frames of Mind: The Theory of Multiple Intelligences*, Basic Books, NY, 1983 and Gardner, H., *Intelligence Reframed: Multiple Intelligences for the 21st Century*, Basic Books, NY 1999.

Figure 2. Pictorial Representation of Multiple Intelligences.
© j. carlson-pickering, ***M.I. Smart!*** Program, found in
http://www.chariho.k12.ri.us/curriculum/MISmart/MImapDef.HTM

Gardner's research has supported the existence of these "intelligences" particularly arguing that they are located in different areas of the brain and can either work together or independently. Most importantly for the educational system, Gardner argues that multiple intelligence can be nurtured and strengthened, or ignored and weakened, and that education can be improved by addressing the multiple intelligences of students. Table 3 by Armstrong (1995) seeks to identify "ways of learning" associated with the abilities, capacities, sensitivities and propensities in each one of the intelligences. Thus, for each of the intelligences, he distinguishes "how children **think**," "what they **love** to do" and "the resources they **need**."

Table 3. Eight Ways of Learning			
Children who are highly:	**Think**	**Love**	**Need**
Linguistic	in words	reading, writing, telling stories, playing word games	books, tapes, writing tools, paper, diaries, dialogue, discussion, debate, stories
Logical-Mathematical	experimenting, questioning, figuring out logical puzzles, calculating	by reasoning	materials to experiment with, science materials, manipulatives, trips to the planetarium and science museum
Spatial	in images and pictures	designing, drawing, visualizing, doodling	art, LEGOs, video, movies, slides, imagination games, mazes, puzzles, illustrated books, trips to art museums
Bodily-Kinesthetic	through somatic sensations	dancing, running, jumping, building, touching, gesturing	role play, drama, movement, things to build, sports and physical games, tactile experiences, hands-on learning
Musical	via rhythms and melodies	singing, whistling, humming, tapping feet and hands, listening	sing-along time, trips to concerts, music playing at home and school, musical instruments
Interpersonal	by bouncing ideas off other people	leading, organizing, relating, manipulating, mediating, partying	friends, group games, social gatherings, community events, clubs, mentors/apprenticeships
Intrapersonal	in relation to their needs, feelings, and goals	setting goals, meditating, dreaming, planning, reflecting	secret places, time alone, self-paced projects, choices
Naturalist	through nature and natural forms	playing with pets, gardening, investigating nature, raising animals, caring for planet earth	access to nature, opportunities for interacting with animals, tools for investigating nature (e.g., magnifying glass, binoculars)

Source. *Armstrong, T. , Multiple Intelligences in the Classroom*, Association for Supervision and Curriculum development, Alexandria (Virginia), 1995.

Many schools, teachers and educational developers are today working on the instrumental development and implementation of the conceptual approach of "multiple intelligences." Two useful websites containing resources and activities are http://oops.bizland.com/mi.html and http://surfaquarium.com/im.htm. In European project LEIPS (*Learning about e-Learning Innovation Activities in Schools*),[6] the City of Naestved is using "multiple intelligences" to define and implement a "journal/newspaper" school activity seeking to *achieve development of self-esteem in the context of the learning community* (fundamental value). This would be achieved through (a) students' creation of satisfactory solutions of self-chosen disciplinary tasks and problems within the framework of the learning community, and (b) students' critical, deliberate and constructive use of ICT (including all kind of knowledge). At the level of individual local project, students are encouraged by teachers to work up and communicate relevant topics in a self-dependent and purposeful way, as well as to substantiate their choices and decisions in the context of the learning community.

[6] Website address at http://www.leips.org.

In sum, the approach of multiple intelligences does highlight the strategic importance of reaching "personalized" learning within systematically orchestrated "community-individual dialectics of lifelong learning." The activities emerged around the approach also help advance in the practical implementation of the approach to improve education and learning processes, including the use of new technologies. It is not the purpose of the MI approach, however, to deal systematically with the nature of the processes on innovation implied in these processes. This is the theme of these paper.

4 Challenges on the Way of the "Promised Land" of ICT-based Innovation in Education

The goals and wishes for the educational system of the 21s century are undoubtedly exciting, promising and challenging as seen from the previous sections. However, as expected, the transformations implied in their achievement is not as straightforward as political and educational authorities would wish it to be. A complex set of issues, factors and processes are involved from availability of ICT resources to teacher's training and, more broadly, deep change in the organization and cultures of schools. An immediate factor is that processes of transformation of educational systems do not start from scratch. They start from what exist, with all the historical legacies in terms of equipment, practices, salaries, skills, motivation and attitudes of people, etc. across the system (i.e., schools, authorities, and all other relevant stakeholders).

In this respect, there are often complains about lack of resources and crumbling schools and motivation against backgrounds of conflict with the authorities, etc. In these circumstances, the gap between goals and desires may look unbridgeable, an ocean in which the impact of even some of best efforts is drowned by the waves of difficulties. Compare for instance the list of ingredients for "high quality professional development" in Table 3 with the situation of many Italian schools described recently by the newspaper *La Repubblica*.

> La scuola pubblica italiana é un barcone pieno di falle e di toppe, imbarca acqua ogni anno di più e spesso rischia il naufragio. Gli insegnanti si percepiscono da tempo come una classe sociale umiliata e offesa, faticano a ritrovare un ruolo, una dignità, un senso, stentano addirittura a far quadrare i loro modesti bilanci. … Gli edifici spesso sono cadenti, cupi, mortificanti. Le aule sono imbrattate di scritte, le serrande crollano come le illusioni e ben presto anche le alunni percepiscono il clima de decadenza, lo introiettano, lo trasformano in disamore e sfiducia. Ogni anno si dibatte sulla nuova impostazione della scuola, si propongono nuove riforme, ma tutto evapora nell'astrattezza più fumo sa.[7]

Table 3. Ingredients of High Quality Professional Development

- Has the goal of improving student learning at the heart of every school endeavor
- Helps teachers and other school staff meet the future needs of students who learn in different ways and who come from diverse cultural, linguistic, and socioeconomic backgrounds
- Provides adequate time for inquiry, reflection, and mentoring and is an important part of the normal working day of all public school educators
- Is rigorous, sustained, and adequate to the long-term change of practice
- Is directed toward teachers' intellectual development and leadership
- Fosters a deepening of subject-matter knowledge, a greater understanding of learning, and a greater appreciation of students' needs
- Is designed and directed by teachers, incorporates the best principles of adult learning, and involves shared decisions designed to improve the school
- Balances individual priorities with school and district needs and advances the profession as a whole
- Makes best use of new technologies
- Is site based and supportive of a clearly articulated vision for student

[7] Lodoli, M., L'Agonia delle Statali, *La Repubblica*, 4 September 2003, pp.1 and 15.

Source: National Foundation for the Improvement of Education. *Teachers Take Charge of Their Learning: Transforming Professional Development for Student Success." Executive Summary*. NFIE, (1996): 7-8, found in http://www2.edc.org/LNT/news/Issue5/NFIE-table.htm

Sure *La Repubblica* is strong critic of the incumbent Italian government, and this may colour the language, but very few people would be able to argue that Italian schools have reached the "nirvana" of Table 3. Indeed, without entering into the merit of the Moratti reform of education, the very fact of the existence of reform bears witness to the need for change in the system to be able to cope with the demands of the 21st century.

The state of educational policy itself, however, has also been critcised as inadequate to face the challenge of 21st century educational goals. Thus,

> despite the very long-term aims and impacts of schooling, a great deal of educational policy and practice continues to be dominated by the short term, leaving them ill-equipped to deal with complexity and change. The necessary "tools", even the vocabulary for long-term thinking, are largely lacking. [Furthermore] … despite education being overtly about knowledge itself, its own knowledge base remains largely tacit, fragmented and underdeveloped.[8]

More often than not, this is the context faced by school and/or policy innovators seeking to implement information and communications technologies to improve education. In this context, a systematically orchestrated "community-individual dialectics of lifelong learning" is clearly a hard challenge to achieve.

5 The Importance of Holistic Approaches to the Understanding and Practice of ICT-based Innovation in Education

Figure 3 provides an idea of the importance of taking a holistic approach to the understanding of conditions and requisites for successful ICT-based innovation in education. It shows the multiple elements and influences involved in making a success of processes of ICT-based innovations in education. Thus, *access* to infrastructure, finance, etc. must go hand in hand with cultural and political *acceptance*, particularly, from the educational establishment. At the same time, these aspects do not go far without *availability* of capacity-building and content-ware experts. The entire ensemble makes clear that, although a holistic process may start anywhere, it is the integrated view that counts when addressing the transformation of the system.

Of course, piecemeal change is always a possibility and, indeed, easier and cheaper but, for the same reason it is not likely to make substantial inroad in the pursuit of ambitious and challenging goals such as the ones associated with 21st century skills.

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[8] OECD/IFP (International Futures Programme), *"Schooling for Tomorrow: The 'Toolbox for Forward-Thinking, Innovation, and School System Change' – Analytical, Methodological and Operational Implications"* OECD/IFIP, Paris, 2003.

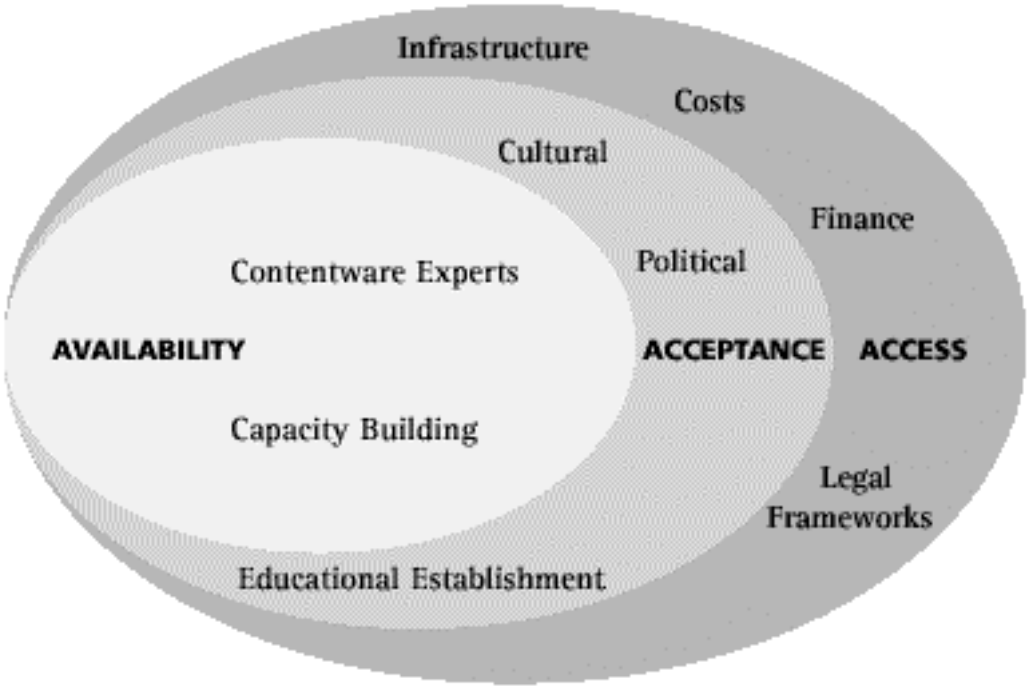


Figure 4. Prerequisites and Constraints in the Use of Technology for Education

Source. Haddad, W. and Draxler , "ICT for Education: Prerequisite and Constraints" in Haddad, W. and Draxler, A. (eds), *Technologies for Education: Potentials, Parameters and Prospects*, UNESCO and AED, Paris and Washington, 2002. pp.42-56, Figure in p.43.

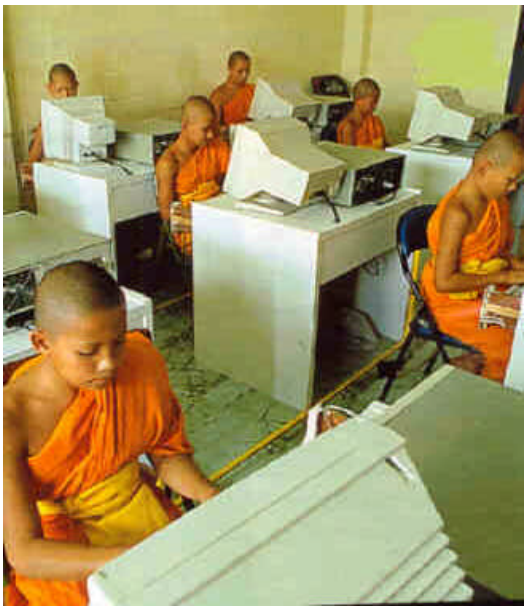
5.1 Distinguishing Installation from Implementation of ICTs

It has long been recognised that social environment and cognitive processes in schools are deeply interrelated.[9] As the two pictures in Figure 5 intend to illustrate, the introduction of computers in a school can constitute an *installation* in an unchanged environment -picture (a)- normally leading to the "gathering-dust" syndrome of equipment sitting under-utilised or without use. At the other extreme, it can be the full integration of computers into the classroom, in which case a deep re-organization of interactions involving between students, teachers and ICTs takes place with simultaneous pedagogical changes.[10]

[9] Vygotsky, L., *Thought and Language*, MIT Press, Cambridge Massachusetts, 1986. (1st edition 1934).

[10] Newman, D., Opportunities for Research on the Organisational Impact of School Computers, *Educational Researcher*, Vol.19. No.3, 1990, pp. 8-13.

(a) Installation of computer in existing class



(b) Fully computerized class

Figure 5. Pictorial Examples of Two Types of Use of Computers in the Classroom
Source. Salvatore, E., *Nuove Tecnologie Didattiche. Innovazione, Cambiamento, Disagio,* Presentation given to *Convegno Nazionale di Studi*, Scuola, Societá, Cultura. Processi in Corso e Scenari Futuri, 30 Marzo 2001, Salerno, Italy.

A study by the US Center for Technology in Education in 1990 found that teachers who used computers in normal activity transformed substantially their roles. Thus,

> "(…) l'uso del computer trasformava profondamente il ruolo dell'insegnante: cambiavano le aspettative dei docenti nei confronti dei risultati che gli studenti dovevano raggiungere, c'era più tempo per gli interventi personalizzati, e l'insegnante agiva maggiormente come facilitatore dell'apprendimento. (…) una delle conclusioni (…) era l'assoluta necessità di mettere in atto, nell'organizzazione scolastica, cambiamenti in grado di permettere agli insegnanti di sviluppare ulteriormente il lavoro basato sul computer.[11]

Of course, the fully computerized class shown in picture (b) of Figure 5 may still be a class to learn about computers as an specific school subject, in isolation of other curricular subjects such Mathematics, History or English. In this case, ICTs are treated as a specialist body of knowledge and as instruments of learning about themselves rather than instruments of learning for all subjects across the educational curriculum. This restricted integration of computers in the educational curriculum has been referred to as the 'sanitisation' and 'technicalisation' of computers.[12]

5.2 Conditions and Requisites for Effective Implementation ICT in Schools

Many studies on ICT-based experiences in schools have been conducted in an effort to learn about the conditions and requisites for successful implementation of computers in schools. Other studies or reports have been written by teachers or educational practitioners reflecting about their own experiences with computers and identifying lessons for others.

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[11] Bagnara, S., Butera, F., and Failla, A., *Scuole con il Computer: professioni e tecnologie nella scuola che cambia*, Etas Libri, Milano 1998, Introduction.

[12] Papert, S., *The Children's Machine: Re-thinking School in the Age of the Computer*, Basic Books, NY, 1993.

For instance in its "1998 synthesis" the UK organization BECTA identified a number of prerequisites helping stimulate in teachers a favourable attitude towards the change of role they face with ICTs.[13]

- Positive attitude towards ICTs
- Understanding of the educational potential of ICTs
- Capacity of effective use of ICTs within the educational curriculum
- Capacity of ICT management in the classroom
- Capacity of evaluation of ICT use in the school
- Capacity to guarantee differentiation and graduality in the use of technological competence in order to widen the range of resources and continuous updating

Becker (1994) focused on the practice of what he called "exemplary computer-using teachers" and identified the the following aspects as important to the realisation of the potential of computers in schools.

- Computers are used for outputs of consequence to pupils (e.g., newsletters, course work, brochures or diary designs).
- Schools with an ICT learning environment do not necessarily have a high ratio of computers to pupils. Exemplary teachers often make class presentations using a computer and prefer to work with pupils in groups rather than on individual tasks.
- Schools are well-resourced with technician support and often include in the staff a dedicated teacher as computer pedagogic expert.
- Schools in which exemplary teachers flourish often invested double the district average of in-service training. This training often reached deeply into the subject curriculum, often combining elements of course work between subjects.
- Schools supported teachers to have computers at home and to experiment with new ways of using them with classes.[14]

The training of teachers to adopt and use the new technology has logically received much attention given (a) their frontline position, (b) expected change of their role, and (c) resistance to change as a result of preconceptions, fears and expectations about computers (i.e., "computerphobia"[15]) and other reasons.

The picture however is not always positive. Thus, according to Boe (1989), “A key weak factor in implementation is inadequate teacher training.”[16] A similar finding highlighted the strong significance of preparatory teacher training of suitable quality.[17] In turn, Reinen and Plomp (1993) report a close correlation between the degree of use of computers in classrooms and the breadth and

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[13] BECTA Synthesis, 1998.

[14] Becker, H., How Exemplary Computer-using Teachers Differ from Other Teachers: Implications for Realising the Potential of Computers in Schools, *Journal of Research on Computing in Education 1* (2), 2000, pp. 274-293.
Becker also finds that 5% of teachers can be labelled exemplar in their use of computers and they are likely to be male and have a good degree.

[15] Selwyn, N., Teaching Information Technology To the ‘Computer Shy’: A Theoretical Approach to a Practical Problem, *Journal of Vocational Education and Training*, Vol. 49, No. 3, 1997, pp. 395-408. Also, Jay, T. Computerphobia: What to Do About It, *Educational Technology*, Vol. 21, 1981, pp.47-48.

[16] Boe, T., The Next Step for Educators and the Technology Industry: Investing in Teachers, *Educational Technology*, Vol.29, No.3, 1989, pp.39-44. Quotation in p.39.

[17] Ryan, A., Meta-Analysis of Achievement Effects of Microcomputer Applications in Elementary Schools, *Educational Administration Quarterly*, Vol.27, No.2, 1991, pp.161-184.

quality of training completed by teachers.[18] Thus, competence from effective training results in confidence to use effectively the technology in the classroom,[19] for instance, through pedagogical strategies that make use of the interactive potential of computers in specific lessons.[20]

An important first phase of a good ICT training programme for teachers assess the state of ICT skills among teachers and seek to deal effectively with any existing "computerphobia" rooted in preconceptions, fears and expectations about computers. In this respect, Selwyn (1997) argues that to face "computerphobia," training approaches should make individuals feel that their views and expectations of ICT use are similar to those of other members of the group. They should also demystify computers, presenting them as tools rather than daunting machines.

Another critical element for teachers' training is focus on relevant problems and problem solving, that is, finding solutions for challenging situations such as those they may face in real life. This is particularly important for adult learners as argued by Knowles (1984)[21] and substantiated by the "constructivist" approach[22] to learning that emphasizes hands-on problem solving as well as customization of educational curricula to student's prior knowledge.[23] Training must allow and encourage teachers to "play" and take "ownership" of ICTs and the processes of introduction in new learning situations.

Box 1 reproduces a brief story whose lessons provide a good illustration of the application of a successful approach to ICT training in a primary school.[24]

Box 1. What Styles of Computer Training Enhance Teachers' Competence and Confidence to use ICT? Based on the experience of Annandale Primary School (later Millennium Primary School) in the UK

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[18] Reinen, I. and Plomp T., Staff Development as a Condition for Computer Integration, *Studies in Educational Evaluation*, Vol.19, 1993, pp.149–166.

[19] Robertson, S., Calder, J., Fung, P., Jones, A., and O'Shea T., Computer Attitudes in an English Secondary School, *Computers & Education*, Vol.24, No.2, 1995, pp.73-81.

[20] Kulik, J., Kulik, C-L., and Bangert-Drowns R., Effectiveness of Computer-Based Education in Elementary Schools, *Computers in Human Behaviour*, Vol.1, 1985, pp. 59-74.

[21] Knowles, M., *The Adult Learner: A Neglected Species*, Gulf Publishing Company, London, Sept. 1984.

[22] In the eyes of constructivism," instruction must do both: tap into the experiences and contexts that make students willing and able to learn and facilitate extrapolation and or filling in of gaps. See Bruner, J., *Toward a Theory of Instruction*, Harvard University Press, Camb., Mass., 1966. Bruner, J., *Actual Minds, Possible Worlds*, Harvard University Press, Camb., Mass., 1986. Bruner, J., *Acts of Meaning*, Harvard University Press, Camb., Mass., 1990. In his 1966 book Bruner states that a theory of instruction should address four major aspects: (1) predisposition towards learning, (2) the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner, (3) the most effective sequences in which to present material, and (4) the nature and pacing of rewards and punishments. Good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information.
A good collection of resources on the theory of "constructivism" can be found at the internet address: http://carbon.cudenver.edu/~mryder/itc_data/constructivism.html .

[23] Kelly's "personal construct theory" (PCT) also stresses similar points. Back in 1955, using a model of *man-the-scientist* , he argued that the individual creates his or her own ways of seeing the world in which he lives; the world does not create them for him; (s)he builds *constructs* and tries them on for size; the constructs are sometimes organized into systems, group of constructs which embody subordinate and superordinate relationships; the same events can often be viewed in the light of two or more systems, yet the events do not belong to any system; and the individual's practical systems have particular foci and limited ranges of convenience. See Kelly, G., *The Psychology of Personal Constructs* (2 vols.), Norton, NY, 1955. Also, Maher, B. (ed.), *Clinical Psychology and Personality: The Selected Papers of George Kelly*, Wiley, NY, 1969. See also Stewart, V. *Enquiry Within*, published by Enquire Within Developments Limited, 1997, http://www.EnquireWithin.co.nz. A good overview, list of resources and related articles on Personal Construct Theory are found at http://www.brint.com/PCT.htm

[24] Edmondson, A., *What Styles of Computer Training Enhance Teachers' Competence and Confidence to use ICT?* , a BECTA study found in http://www.becta.org.uk/research/reports/docs/cpd_edmondson.pdf.

Background

Late in the summer term of 1999, the staff and pupils of Annandale Primary, a mainstream primary school of 240 pupils, were informed of a proposal to move them into a brand-new building on the Greenwich peninsula. The school has a very mixed socio-economic intake, with a catchment area encompassing both private and social housing; 35 per cent of the pupils have free school meals, 25 per cent have English as an additional language (EAL) and 26 per cent have special educational needs. In February 2001, Annandale Primary moved into the new building and was renamed Millennium Primary School.

Millennium Primary is a joint project with the DfES, the local education authority and the school, with technical input from a hardware provider. The school is an architecturally designed 'high tech' building, which has state-of-the-art classrooms, each with an interactive whiteboard and three high-specification desktops, with all the necessary peripherals – scanners, printers, digital cameras and web cameras. There is a set of laptops and PC tablets with wireless access to a managed network and the school has a broadband connection to the Internet. The school is a 'test bed' for new hardware and software and is expected to consistently demonstrate best practice in teaching in general and, in particular, in the use of ICT to enhance teaching and learning across the curriculum.

KEY LESSONS

- Knowing the ICT skill level and attitudes of your staff towards computers is crucial in designing training that is sympathetic to their needs; plan opportunities to discuss ideas and anxieties.
- Training is most successful when it is delivered at school and focused on skills that are relevant to teachers' everyday lives; be involved with the planning and the design of the training, perhaps with other schools in your cluster.
- 'Play' is the most important feature of the instructional style; training that incorporates plenty of time for sharing skills and ideas and then experimenting with them is very successful.
- Successful training needs to be well led and there needs to be a supportive learning culture amongst the staff; mutual support of the staff is not only incredibly effective but also economical.
- The most significant element for continuing the development of teachers' ICT skills is for them to have their own laptops; these, in conjunction with the interactive whiteboards, have the greatest impact on enhancing teaching.

Source. Andrea Edmondson, teacher at Annandale primary and ICT co-ordinator at the Greenwich Millennium Primary School until end of 2002. The discussion paper, published by BECTA, if found at http://www.becta.org.uk/research/reports/docs/cpd_edmondson.pdf.

On the other hand, the work of Bork and Yoshii (2002) highlights the importance of customization of educational material to student's prior knowledge by looking at the emerging global dimension of learning. They note that "there are many different languages and cultures in the world. If learning material is to be usable with many students in the world, we need to be concerned with the cultural and language differences among students. We need global materials that meet individual cultural needs."[25] They identify a number of essential characteristics that the "global educational materials" must satisfy to succeed in "universal global education and learning." These are shown in Table 4.

[25] Bork A. and Yoshii, R., *Computer-based Learning Units for Many Languages and Cultures, Information and Computer Science*, University of California and Department of Computer Science, California State University, 2002.

Table 4. Essential Characteristics in Global Educational Material for Universal Global Education and Learning
Individualization: The material must adapt to each user. If we are to pursue global education, we will have a great many different types of users. Each user will have unique abilities and learning problems. The learning material must recognize these, and so must treat each person as an individual.
Affordability: The material must be affordable, both by individuals and by countries. In making this calculation, we must take into account all expenses for development and delivery of the learning materials, including profit if the materials are developed by a for-profit organization.
Collaborative Learning: The material must allow collaborative learning. We imagine a group of two to three students sitting around a computer. This is especially important for students who are not familiar with computers.
Mastery: The learning material should strive for success for all users. Failure is not acceptable.
Languages: The material must be available in many different languages of the world with many different writing systems. This cannot simply use direct translations since each culture has its own ways of expressing the same concept or feeling.
Culture: Learning units should match and respect the culture of each group. This includes not just the types of materials to be used but also how the materials will be presented.
Motivating: The leaming units must be intrinsically motivating. Many of the usual student "threats", such as grades, may not be available. Again, what is motivating may depend on the user's culture. This goal is especially important for the countries in which only certain types of students will get attention from a human instructor.
Delivery: Delivery mechanisms must be available for reaching everyone, even very poor students. This must include environments without schools.

Source**.** Bork A. and Yoshii, R., *Computer-based Learning Units for Many Languages and Cultures, Information and Computer Science,* University of California and Department of Computer Science, California State University, 2002.

Finally, it is worth looking at the achievements of one advanced and mature case of ICT-based innovation in school. It helps to highlight the achievements that are not just possible but, indeed, happening in schools that have approached holistically and systematically the implementation of ICTs to improve the educational and learning processes for the benefit of all stakeholders. This is the case shown in Box 2 of Bendigo Senior Secondary College (BSSC) in Australia, which has been pursuing an agenda of school change across the board.[26] Bendigo is in fact one of the 7 "laboratories" schools of the Navigator Schools Project launched in 1995 by the Department of Education, Employment and Training in the State of Victoria, Australia. The aim of the Navigator project is to develop:

- Models of best methodologies teachers can use in classrooms in which computers are primarily used as tools for acquiring information, thinking and expression;
- Increased understanding of how teaching and learning changes in such classrooms;
- Models of administrative arrangements that facilitate and support improved student learning;
- Models to increase and improve parent-school interaction;
- Expanded teacher professional development opportunities to support the adoption of improved teaching practices;
- Ongoing evaluation of, and advice on, curriculum materials, equipment and software;
- Support structures for other schools that chose to undergo such transformation.

Box 2 reproduces *in extenso* the main pillars of Bendigo's holistic agenda for change, the list of multiple areas in this programme for change, and some of the main effects of the changes.

[26] Toomey, R. and Ekin-Smyth, C., *ICT and the Quality of Learning. An Overview of the Australian Case Studies,* OECD/CERI ICT Program, 14 May 2001, found in http://www.oecd.org/dataoecd/31/52/2732684.pdf.

Box 2. ICT-based innovation at Bendigo Senior Secondary College (BSSC), Australia

Background

The agenda for change at Bendigo Senior Secondary College (BSSC) rested on three main pillars:

- The development of a consensus within the school community that teaching and learning have to be active, constructivist and experiential and that classrooms have to change to accommodate such an approach
- The belief that well integrated use of ICT enhances teaching and learning
- The belief that schools have to be restructured to support the changed classroom.

The key goal of the change effort was to improve the quality of teaching and learning at the college, through a combination of (a) incorporation and effective use of ICT, (b) a reconsideration of teaching and learning approaches and (c) an organisational restructure. ICT was the catalyst for the reform effort, playing a major role in the transformation of teaching and learning and in the reorganisation of management and administration. Over the past seven years the school has:

- Revised its overall organisational and management structure
- Reorganised its decision making processes and procedures
- Expanded and revised its curriculum arrangements
- Developed an extensive in-house professional development program
- Established a formal annual review and appraisal process for all staff
- Radically revised its timetable and the pattern of student access to the school and staff
- Redesigned much of the classroom space so as to accommodate better student centred-teacher guided learning
- Improved the sense of professionalism amongst the staff and increased staff?s work ethic
- Integrated the school into the family, business and wider education community aspects of Bendigo
- Firmly located itself as an international leading school in the integration of ICT into a wholly changed school setting.

Some of the main effects of the changes have been:

- Improved staff morale
- Increased skill levels in using ICT
- Substantially improved externally assessed student learning outcomes
- Increased parental satisfaction with the school
- Increased sense of professionalism on the part of staff
- Increased work ethic reported by staff.

Toomey, R. and Ekin-Smyth, C., *ICT and the Quality of Learning. An Overview of the Australian Case Studies*, OECD/CERI ICT Program, 14 May 2001, found in http://www.oecd.org/dataoecd/31/52/2732684.pdf.

6 Second Information Technology Study in Education (SITES)[27]

The recent results of the global SITES study provide a fitting finish to this paper and its focus on the question "what is happening with ICT-based innovation in educational systems?" These results are based on SITES' study of 174 case studies of ICT-based innovative pedagogical practice from the 28 participating countries. The cases were selected on the basis of effective ICT-based change in classrom practice and, most importantly for our purposes, they "were not meant to represent typical practice in a country. Rather, they represent the aspirations that each country has for the use of ICT to change and improve education."[28] In other words, the practices identified by the study represent the leading edge of ICT-based educational practice in schools in the world.

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[27] Kozma, R. (ed.), *Technology, Innovation and Education Change. A Global Perspective*, International Society for Technology in Education, PLACE, 2003.

[28] Ibid. Kozma, R., Summary and Implications for ICT-based Educational Change, in Kozma, R. (ed.), *Technology, Innovation and Education Change. A Global Perspective*, International Society for Technology in Education, PLACE, 2003, pp. 217-239. Quotation on p. 219.

The SITES study identified eight clusters or patterns of ICT-supported classroom practices. These are shown in Table 5.

Table 5. Clusters or Patterns of ICT-supported Classroom Practices

Type of Cluster	*Primarily Characterized by:*
Tool Use	High use of productivity tools and email
Student Collaborative Research	Students collaborating with each other in their classes to conduct research and analyze data. Teachers lectured, advised students, created structure for their students, and monitored their results.
Information Management	ICT used to support the search for information, the creation of products, the monitoring students, and planning Students searched for information, solved problems, published their results, and assess themselves and each other. Teachers created structure and designed material.
Teacher Collaboration	Teachers collaborating with students, their colleagues in the school, and others outside the school. Students picked their own task. ICT used to support the creation of products
Outside Collaboration	Students collaborated with others outside the school with ICT supporting communication
Product Creation	Students designed products and used ICT to support this process. Teachers created structure and gave advice
Tutorial	Use of tutorial software for tutoring, drill and practice
Undefined Cluster	Lack of a unique pattern of practice

The SITES study also tended to confirm that pedagogical practices are shifting from the traditional "provider" to the "facilitator" model of teachers' practice. Table 6 shows the set of ICT-supported innovative pedagogical practices practised by teachers across all the "clusters."

Table 6. Common Set of ICT-supported Innovative Pedagogical Practices - Student Collaboration Model (Core Model)

Specific Shift in Teachers' Practice towards	*% of 174 schools*
Adviser to students (rather than knowledge provider)	90%
Creator of structures for student activities	80%
Monitor of student progress	76%
Students collaborated with others in their classes	74%
Use of Email	68%
Use of Productivity tools	78%
ICT-supported search for information	77%
ICT-supported communication	55%

Three additional pedagogical models augment the core "student collaboration" model. These are as the "product model," "research model," and "outside collaboration model," all of them identified in Table 7.

Table 7. Three Additional Pedagogical Models Augmenting the Core Model : Product Model, Research Model, Outside Collaboration Model	
Product Model: Specific Shift in Pedagogical Practice towards	***% of 174 schools***
Teachers and students created products	56% and 61%
Teachers collaborated with their colleagues in product creation	59%
Students published the result of their work	66%
Students used multimedia, in addition to email and productivity tools of the model above	74%
Research Model: Specific Shift in Pedagogical Practice towards	***% of 174 schools***
Students conducted research and solved problems, using	39% and 33%
✍ Web resources	71%
✍ Local area networks	41%
✍ Multimedia, productivity tools and email to support product creation and planning	26%
Outside Collaboration Model: Specific Shift in Pedagogical Practice towards	***% of 174 schools***
Students collaborated with outside actors (and other students in the class)	26%
Teachers collaborated with peers	59%

The pedagogical models and clusters of Tables 6 and 7 are combined in Table 8 to highlight the kind of activities and skills often associated with a preparation for the knowledge economy and the information society. In this respect, the evidence from the SITES study is that the type of "21st century skills" identified by most US and European educational policy reports seem to be emerging in those schools leading ICT-based innovation across the world. Thus, the study witnessed "ICT beginning to break down some of the traditional barriers within the classroom." On the other hand, the study also found only few cases in which teachers and students connected and collaborated with others outside the classroom. In most of these cases, the communication was with other teachers and students. Very few innovations involved collaboration with scientists, professors, and business people, and far fewer cases connected parents to the classroom. In short, it is still rare to find ICT being used to break down the schoolhouse walls, even in these innovative classrooms around the world.[29] This finding underscores the fact that the potential of ICT-based innovation is yet to reach more radical transformation of educational practices inside the schools systems of even the most advanced experiences.

<table>
<tr><th colspan="4">Table 8. Cluster-Model Combination and the Changing Teacher and Students Skills</th></tr>
<tr><th>Type of Cluster</th><th>Core Student Collaboration Model</th><th>Student Research Model</th><th>Product Model</th></tr>
<tr><td>Tool Use</td><td colspan="2" rowspan="2">Associated with:
Teacher acquisition of new pedagogical skills
Student acquisition of ICT skills, problem-solving skills, and team or collaborative skills</td><td></td></tr>
<tr><td>Student Collaborative Research</td><td></td></tr>
<tr><td>Information Management</td><td colspan="3">Associated with:
Student acquisition of communication skills and information handling skills</td></tr>
<tr><td>Teacher Collaboration</td><td></td><td></td><td></td></tr>
<tr><td>Outside Collaboration</td><td></td><td></td><td></td></tr>
<tr><td>Product Creation</td><td></td><td></td><td></td></tr>
<tr><td>Tutorial</td><td></td><td></td><td></td></tr>
<tr><td>Undefined Cluster</td><td></td><td></td><td></td></tr>
</table>

The SITES study also looked for evidence of innovation in relating the ICT and the curriculum. It found innovations evenly distributed across different types of schools and also across a wide variety of subjects. The type of innovation however was not mainly related to new content or new goals. In fact only 27% of the 174 cases reported new content and 37% new goals.

[29] Ibid., p.221.

In comparison, reorganisation of current content was reported in 68% of cases and reallocation of time in 36%. Regarding ICT-based curricular innovation, the interesting finding is that only 32 of the 174 cases reported that "the goals or content of the curriculum changed and ICT added value to these changes."[30] The SITES study notes that in all cases, the primary impact of innovation was on the acquisition of ICT skills by students (75%) and teachers (63%). This was accompanied by students' acquisition of positive attitudes towards learning (68%) and the acquisition of knowledge (63%) and collaboration skills (63%). In general the SITES study does not find a widespread change in ICT-supported curriculum and assessment. This "was relatively rare and often quite modest."[31] National policy is identified as a limiting factor for curricular innovation., thus "it appears that for the most part national policies are not yet in place that can mobilize ICT in support of significant curriculum change and education reform."[32]

Perhaps some of the most relevant findings of the SITES report concern the "school context, sustainability and transferability of innovations," as they refer directly to the ability of schools to sustain, scale up and transfer an ICT-based innovation to other classrooms and schools. The results are quite revealing of the difficulties of ICT-based innovation even in the selection of advanced schools making up the study. Three-quarters of the 174 schools stated that the "innovation had been sustained for at least a year," but evidence for transfer was weaker, with only 41% of the schools claiming such activity. At the same time, only 59 of the 174 schools provided evidence that the innovations had been sustained and transferred, confirming the substantial challenge implied in the sustainability and scaling up of innovations in schools. Table 9 shows what the study identified as the "essential" and "contributory" requirements for sustainability.

Table 9. Requirements for Sustainability

Essential	***Contributory***
Teacher support for the innovation (energy and commitment)	Existence of support from others in the school
Student support, as motivation for teachers' efforts	Existence of support from external sources
Perceived value (increased students knowledge and metacognitive skills and student acquisition of technology skills	Innovation champions
Teacher professional development (including ICT and pedagogical skills)	Funding
Administrator's support and professional development	Supportive policies and plans
	Connection with national ICT plans that provided resources

"Transfer" of innovation came out as particularly difficult in the experiences looked at by the SITES study, including the most advanced. The study suggests that 'transfer is dependent on an adequate infrastructure and resources in the new setting. Teachers must perceive the value of the innovation for accomplishing their classroom goals. Plans and policies also need to be in place that encourage the transfer of the innovation."[33]

Table 10 goes further in its confirmation that, at present, ICT-based processes of educational innovation have a long-way to go before effective fulfilment of the challenging goals articulated in US and European educational policy documents, particularly with reference to 21st century skills. The SITES study concludes: "for the most part they have not been realized in the schools."

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[30] Ibid., p.222.

[31] Ibid., p.224.

[32] Ibid.

[33] Ibid., p.225.

Table 10. Policy-makers' Goals Showing Weak Evidence in the Case Studies
sustained and transferred innovations
successful innovations passing quickly and efficiently to other classrooms and schools ("ripple effect").
innovations reflecting systematically in the curriculum new goals of students' development of "knowledge-economy" skills (e.g., metacognition, information handling, problem solving, and working in teams)
collaboration or connection with outside actors (other than with other teachers and students) reflecting connection of classroom with the real world as preparation for the knowledge society
e-inclusion innovations providing particular benefits to groups of students with special needs (e.g., low socio-economic status or ethnic or language minorities)

SITES identifies the rigidity of national curriculum and assessment methods as major constraints on the innovations teachers can introduce in the classrooms. Consequently, they call upon those countries committed to planning for the information society to go beyond the mere incorporation of ICT skills into their curriculum. They must also incorporate - in both the national curriculum and associated methods of assessment- skills related to information management, knowledge creation, investigation and collaboration into the content and goals of their curricular frameworks. In addition, the changes must be aligned in such a way that (a) the curriculum reflects new goals and content, (b) teachers are trained in how to use ICT to incorporate the new goals and content in their classes, and (c) assessment is designed to measure the attainment of these new skills.[34] In practice, this demands from policy-makers the definition and implementation of "more specific practice-based programs by which these policies will affect schools and classrooms."[35]

The results of the SITES study as well as the stories briefly described in Boxes 1 and 2 tell of progress in the realization of the promise of ICT-based innovation in schools. They do not unveil however, in a systematic and profound fashion, the general nature of processes of ICT-based innovation, and hence, the elements, dimensions, and factors involved in success and/or failure. This understanding is very much required if the policy and practice of ICT-based educational innovation are to enhance their effectiveness and progress towards the 21st century learning environments.

[34] Ibid., p.233.

[35] Ibid., p.232.

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INTERNET RESOURCES

http://www.brint.com/PCT.htm, for a good overview, list of resources and related articles on Personal Construct Theory.

http://carbon.cudenver.edu/~mryder/itc_data/constructivism.html , good site on "constructivism" with a rich summary of links and references on key authors.

http://oops.bizland.com/mi.html, website containing a list with good link to resources on Multiple Intelligence apt for educators.

http://surfaquarium.com/im.htm, website with tools and resources for practical implementation of MI theory into didactics.