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Integrating the Educative Functions of Information and Communications Technology (ICT) in teachers' and learners' toolboxes: a reflection on pedagogical benchmarks for ICT in teacher education

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ABSTRACT The big question about pedagogical benchmarks for information and communications technology (ICT) in teacher training is whether they can be transferred to contexts other than the ones in which the benchmarks have been developed. In this article we reflect on the chances that the benchmarks presented will become really integrated within the heart of the learning and teaching process of teacher training programmes. To understand that process better, we reflect on the concept of professional learning and what that concept has to say about organisational learning and about how the integration process could be further developed. We propose a broad framework for actions of all actors involved: teacher training institutes, their partners (professional development schools), research and development agencies, the teacher trainers, the students, teachers in practice and their pupils. Only a concerted action of collaborative experimenting and professional learning on ICT integration in the learning and teaching processes can lead to the use of ICT as a catalyst for implementing learning arrangements that fit the expectations of the twenty-first century and its youth.

Introduction

The supervision of education and the evaluation of the quality of education are tasks carried out by the Inspectorate for Education, as stated in the Dutch Constitution. Since 2002, the Supervision Act (Wet op het Onderwijstoezicht [WOT]) gives the Inspectorate a legal basis for

independent, professional and public evaluations of the quality of schools and the system. The WOT states that the 'supervision' is 'assigned' to the Inspectorate and entails judging the quality of education (i.e. individual schools as well as the education system as a whole) in accordance with regulations provided by the laws on education. The WOT also states that the Inspectorate, along with evaluating and checking a school's compliance with regulations, should try to improve the quality of education by consulting with the management and staff of the school and the local and regional authorities. The Inspectorate's final task is to report on the quality of schools, and more generally on the development of education.

According to the 2002 report on the Educational Partnership – a programme for the modernisation of teacher training in the Netherlands (van den Dool & van de Kuilen, 2002), there has been alarmingly little progress with respect to information and communications technology (ICT) and the progress that has been made has been quite makeshift in character. Teacher training institutions are going in the right direction, but lack the necessary quality, expertise, intensity, attention, and momentum.

Schools have an acute shortage of expertise, not so much in basic digital skills, but rather in the educational use of ICT. The (lack of) integration of ICT in teacher education curricula for lower secondary (ages 12-15) and upper secondary education (ages 16-18/19) reflects these deficits. The structure and the content of teacher training programmes on ICT in education (ICT-E) are underdeveloped. Nowhere is there a clear definition of a programme relating to ICT integration in education; there are no readers, no textbooks, and no clear entry to the world of knowledge in this area, either for the student body as a whole or for students specialising in ICT-E. Many institutions are so busy defining competencies for students in ICT-E that they either do not know of or make no use of widely available, international examples and benchmarks.

To this end, the Inspectorate has developed 'ICT School Portraits', qualitative investigations of schools that are leaders in the integration of ICT in their education. These portraits depict innovative and inspiring use of ICT within schools. They describe and analyse examples of ICT developments in schools, making them visible to others. They do not presuppose a number of fixed quality criteria, but focus on unexpected innovations and practical solutions that vanguard schools come up with. As such they:

- provide inspiring examples to other schools;
- provide information for policy makers on the actual possibilities of ICT for educational purposes and on the necessary conditions for schools to realise these possibilities;
- in the long term, contribute to the redefinition of common objectives and quality standards for education.

During the last 2 years, over 70 portraits have been made, covering almost all sectors within primary, secondary and vocational education as well as teacher training colleges in Dutch education and in Sweden, Ireland, France, Canada and Scotland.[1]

One of the portraits was on the School of Education at the University for Professional Education of Amsterdam (EFA), because the School had been engaged in a large-scale experimental teacher training innovation programme. The inspectorate visited the EFA in 2001 and reported their findings along the following lines of reasoning which we cite and paraphrase here:[2]

> We are pleased to admit unreservedly that we were duly impressed. ICT has a wealth of educational functions. Various forms of ICT were shown to us. They included use of multimedia, databases, and the Internet and communication functions. The application of ICT within the different areas of specialisation was likewise extremely diverse. Thought had been given to the ICT application best suited to a specific field of specialisation and specific type of didactic problem. We also had an opportunity to see ICT being used in the portfolio that EFA has developed. We were most definitely impressed by all of this. Yet questions still remained. They stemmed mainly from the place of ICT within the student's didactic toolbox and the knowledge within the teaching programme of ICT practices in secondary schools and among pupils in the secondary education system. In particular, we were left with unanswered questions about the systematic attention to educational technology issues of general and specialised didactics. When we refer to education technology, we mean the applications of all kinds of old and new media and tools as part of the total design of the educational process. Education technology is not only an academic discipline; it also provides pointers for the 'didactic toolbox' of teaching staff. The observation that the teacher training programme is still devoting little substantial attention to knowledge and skills in the field of educational technology is not confined to EFA. We (and others) have made the same diagnosis for other teacher training programmes for secondary education. For the teacher training colleges for primary education, too, there is still room for considerable development of structured attention to educational technology within the training programme. This applies all the more in settings where the teacher training programmes are expected to deliver a lot in terms of innovation in the ICT field at schools.

ICT is a means, not an end. For the teacher training college and for the teacher, it is a fundamental piece of equipment. Therefore, there is no option but to devote systematic attention to the question of what place ICT can occupy in the didactic concept and design. Separate attention is required for the questions of what ICT can and cannot do, and where it can and cannot

produce added value. It is clear from various teaching practices that this added value can be achieved. ICT apparently works. We have yet to answer the question of why, when and in which situations.

The question for this article is what the presentation of international benchmarks in the area of ICT-E for teacher education could offer for developing the next steps in the integration of ICT in teacher education. We will elaborate on that question in the next paragraph.

Pedagogical Benchmarks and the Educational Functions of ICT

Three of the five benchmarks reported by Kirschner & Davis in this issue, and discussed in depth in Kirschner & Wopereis (2002), relate to the use of ICT as a tool for the teacher. These are:

Benchmark 2 – ICT as a mindtool

Programmes for teacher training should train aspiring teachers to be able to make use of ICT as mindtools. Mindtools are not specialised software that 'teach' a subject, but rather are computer programs/applications that facilitate meaningful professional thinking and working. Mindtools help users represent what they know as they transform information into knowledge; they are used to engage in, and facilitate, critical thinking and higher-order learning. As a minimum, teachers should have basic competencies involving using mindtools for:

- cooperation (between teachers, teacher educators, and student teachers);
- collaboration on pedagogical projects (with other teachers, experts, designers, etc.).

Benchmark 3 – Educational/pedagogical use of ICT

Programmes for teacher training should train aspiring teachers to be able to make use of ICT within many different educational/pedagogical settings. In other words, not in ad*A*pting their education to ICT, but rather of ad*O*pting ICT in their education. Minimally, teachers should have basic competencies involving using ICT for:

- collaboration/cooperation in both asynchronous (email, discussion lists, web-based forums, listservs) and synchronous (video, audio, chat, whiteboard, file sharing) environments;
- resource-based learning (informing, asking questions, evaluating, comparing).

It is of paramount importance that programmes for teacher training acquaint and prepare aspiring teachers with the effects of ICT on:

- their own role as teacher;
- their students with respect to autonomy, authentic activity, learning styles, situated learning, motivation, disenfranchising.

Benchmark 4 – ICT as a tool for teaching

ICT must be used to meet educational objectives in a way which is integrated into the school programme. This means that aspiring teachers not only know the theory behind why and how to use ICT (a possible danger in Benchmark 3), but must also acquire competencies in:

- adapting technologies TO good/better teaching such that the teaching/learning CAN change for the better;
- planning for individual, group and whole-class activities;
- preparing and producing learning materials with the help of ICT;
- dealing with the possibilities/consequences of using ICT;
- teaching and learning specialist subject(s) with ICT;
- team teaching in situ or at a distance.

These benchmarks offer a good starting point and frame of reference for setting targets to be achieved by teacher training institutions. The definition of competences for students, and the examples of programmes and learning settings within the examples of good practice, can help to orient the developers of innovations. At the same time, when you want to translate the benchmarks in an outline of new learning arrangements within teacher education, there are a lot more questions to be addressed. ICT is not a black box. There are many types of ICT and a wide variety of educational functions that can be fulfilled through ICT.

Educational Functions

Ehrman (1996), in his Triple Challenge study for the Organization for Economic Cooperation and Development [3], has formulated three major functions that ICT could fulfil in education, namely to:

- increase effectiveness of education;
- increase quality of education;
- enlarge access to education and training.

Many ICT protagonists claim that this approach is based upon the idea that the use of ICT will incrementally 'perfect' education; it will make current

practices more effective and efficient. They propose instead that the introduction of ICT will lead to a new educational paradigm, to new forms of learning, with the focus shifting from teaching towards learning. This leads us to the question of what can be said about the relationship between pedagogical concepts and the introduction of ICT into education.

In educational theory, reference is frequently made to the basic pedagogic triangle between the teacher, the learner and the learning content, that describes every educational situation. It is also possible to take into account possible functions of co-learners or the structure and presentation of learning materials. Even the organisation and the management of the learning process and the support system at institutional level can be analysed with regard to their functionality for the primary process of teaching and learning. Indirect influences on the learning and teaching process can be expected from educational publishers, ICT companies, parents, learners at home, educational research, etc.

We introduce the concept of 'educational functions' as a container concept. Educational functions are defined as the learning and teaching functions of all possible actors and factors in the learning and teaching processes. Educational functions of ICT are thus those learning and teaching functions that can be supported through ICT in education. Van Hout-Wolters et al (2000), for example, present a list of learning functions which they classify as preparatory to learning, executive (in the learning itself) and closing learning functions. O'Shea & Scanlon (1997), in turn, present a list of 15 educational functions of the use of new technologies, namely: visualisation, diagnosis, remediation, reflection, memory prostheses, scaffolding, tackling the hypothetical, time travel, autonomy, pacing, redundancy, motivation, groupworking, knowledge integration, and access. In each case the question is whether the teaching and learning functions can be supported by ICT.

Types of Knowledge, Knowledge Literacies and ICT in Education and Training

The Dutch Scientific Council published a major study on the impact of ICT for technology, research, education and media policies (WRR, 2002). In their opinion, education is the most important link in the information society chain. Policy must be directed towards the development of an educational infrastructure where ICT is integrated into the educational system not only in a technological sense, but also in a social (psychological and organisational) sense. This topic is further elaborated by Kirschner (2002), who states that when 'technology mediates the social and educational contexts we speak of "technology affording learning and education". This means that we must hold count with technological, educational, and social affordances' (p. 18). In other words, the integration of ICT into education is much more than boxes and wires; it is about a complete redesign.

What is needed is the pedagogic integration of ICT into education. The Council advises that synergy be sought between the new possibilities of ICT and the development of new insights into educational sciences; that experimentation takes place on a meaningful scale and this play a role in the design phase of innovation; that evaluation of all of this takes place; and that working in knowledge communities be stimulated and rewarded.

ICT needs to be seen as an *enabling technology* which gives new impulses to basic questions such as how to deal with individual differences between learners, how to deliver 'tailor-made' education, and how to make education more appealing for both the learner and the teacher (see also Simons, 2002a).

This means that ICT has to proceed beyond the introductory phase, where substitution – doing things that are already done more effectively and/or efficiently – plays an important role, to one of transformation – where hitherto unachievable goals come within reach (Kirschner et al, 1996). We need to move from 'learning to use ICT' to 'using ICT to learn'.

Simons (2002b) also worked on this problem regarding questions about the role ICT could play in tackling 'key' problems from teachers. According to him, the priorities for ICT are:

- tuning education to prior knowledge and interests;
- facilitating higher-order skills training;
- offering opportunities for contextualisation: authentic contexts, games, simulations, practice, real-life projects and contacts;
- facilitating decontextualisation and reflection;
- helping to organise self-directed learning;
- supporting learning to learn.

In this respect, Simons sees ICT as playing an important role in guiding teachers and learners through three worlds of learning (see Table I).

It appears that when we are talking about the integration of ICT-E into education and teacher training, we will also have to take account of the thinking developing in the area of professional learning. In the area of ICT-E this will mean that there is a need for combinations of research, development work, teacher education and training, and school improvement. What the consequences of the ICT-E benchmarks will be and how the professional community receive this will be elaborated on in the next section.

Adaptive learning	World 1
Traditional learning	Acquire information from experts
Guided learning	Focus on preset tasks and learning goals
Single loop learning	Becoming skilled
	Within frame of reference
Cooperative learning	World 2
Collaborative learning	Develop new ideas/concepts
Inquiry learning	Construct meaning
Reflective learning/	Discuss, find out, inquire, dialogue, criticise,
Double loop learning	evaluate
	Extend frame of reference
Participation	World 3
Expansion learning	Identify new issues
Critical learning	Walking the talk?
Cultural learning	Design new solutions/tools/actions; work
Triple loop learning	Dissemination
Knowledge building	Construct collective meaning/
	Build new frame of reference

Table I. Three kinds of learning contents and approaches (Simons, 2002b).

How the Pedagogical Benchmarks were Received

The quick-scan carried out by the Open University of the Netherlands (Kirschner & Wopereis, 2002) was itself the basis of a group decision session with leading players within the teacher training community in the Netherlands. The following is a short sketch of how the benchmarks were received by this professional community.

Benchmarks and their Implementation

The community was enthusiastic about the benchmarks, but felt that the teacher trainers could and should go even further in their role as educators of tomorrow's educators. The most prevalent comments were:

- The benchmarks present us with a real picture what the integration of ICT-E in the competence profile of the new teacher will mean.
- Good practices should not only be looked for but also actively created.
- Students have to learn to think critically about learning goals and what ICT could contribute to reach these goals.
- We need to place more emphasis on practical research on ICT in education, as well as on the cooperation in this research between teachers, student teachers, and teacher trainers.

- Teacher colleges should become ICT-expertise centres for the educational community.
- Stop adApting education to ICT, adOpt ICT into education.
- Form learning communities with other teachers colleges; if these prove to have 'added value' then they will also be used in education itself.

The meaning of ICT-E developments for teacher training. With respect to what the community thought about the effect that the integration of ICT into the curriculum would/could mean, the participants were fairly critical. This might be due to the fact that the Netherlands has experienced a series of major changes to its educational system in the past 10 years that are unprecedented in its history. Many of these innovations were government led. In the Netherlands, educators speak of 'innovation stress'. The community felt that:

- ICT should/could make teacher training an inspiring experience.
- Teacher training colleges should listen to their students, the schools and the students in those schools when it comes to ICT-E.
- ICT-competent teacher trainers are a prerequisite for educating a generation of ICT-competent teachers.
- ICT-E should play a key role in the accreditation of teacher training institutions.

The meaning of ICT-E competence for aspirant teachers. The professional community saw several things that could be taken on board in programmes for initial teacher education. During the discussions it became clear that ICT-E is not only about skills, but also about knowledge and understanding of the educational functions of ICT, as can be seen in the following statements:

- As long as we continue to speak of ICT as something different ('computer-assisted' ...) and not as normal (no one speaks of 'book-assisted learning'), it will never become a 'normal' part of teaching and learning.
- Teach as you preach: integrate ICT into the 'teaching the teacher' process so that the learners (the graduates) have had experience and not only gained knowledge.
- ICT-E competences of students clearly set out in a digital portfolio should be a prerequisite for graduation and accreditation.

Students should learn to critically reflect on the added value of ICT in the pedagogical context and should be able to argue the case for their use of specific forms of ICT.

Teacher trainers must master the educational use of ICT in their own teaching and should, as with other educational instruments and tools, be able to reflect on the added value.

- ICT-E competences should get as much attention as the other core competences of the teaching profession.

As we can see, there is also a need to develop a kind of 'introduction to educational technology' within the programmes. At this moment the number of textbooks or web sites that can fulfil this challenge seems limited.

The role of other actors in the ICT-E knowledge chain. We also asked the representatives of the teacher training community to reflect on how they could set up a situation in which teacher training institutes could better profit from knowledge production in other parts of the knowledge network. This topic is specifically important in the Dutch context, as there was thus far no role for the teacher training institutions at the universities with regard to professional education in the area of research.

- Regional networks of schools, led by their principals, could deliver a useful platform for exchange of knowledge and expertise.
- Vanguard schools that have extra budgets for development should be required to transfer their products and experiences to others.
- Teacher training agencies as centres of ICT-E expertise should also serve as vanguard schools for their peers.
- Teacher training institutes should link up vanguard schools and schools lagging behind and play an active role in the 'translation' of knowledge from research to practice.
- Each teacher training institute should develop a detailed map of the schools in their region and their ICT-E expertise and start projects between actors that can learn from each other.

In general, the community was clearly receptive to the benchmarks delivered by the international survey, but the strongest message from the session was that a lot of work had yet to be undertaken. There was consensus that, in addition to taking note of and learning from the benchmarks and the good practice from which they were derived, urgent steps needed to be taken to develop knowledge networks, set up knowledge-building projects, translate research findings into educational use of ICT, reflect on practical experiences of schools, students and teachers, and build on that type of codified practical knowledge.

Analyses of ICT integration by the Dutch Inspectorate for Education (2001) showed that 'knowledge and expertise' were the two bottlenecks for further steps in the integration of ICT into education. We deliberately mention knowledge and expertise as two separate aspects. Expertise in our view is necessary – as well as knowledge – because it refers to the process of further competence development and practical application (Bereiter & Scardamalia, 1993). This is also reflected in the findings of Brown & Duguid

(2000), who state: 'Information is on its own not enough to produce actionable knowledge. Practice too is required. And for practice, it's best to look to a community of practitioners' (p. 135). In the next section we will elaborate on these types of communities and the knowledge building necessary for that agenda.

Towards an Agenda for Innovation in ICT-E in Teacher Education

What follows is a short agenda for innovation in teacher education with regard to ICT-E. This agenda must first fit the pedagogical innovations necessary for education and learning in the twenty-first century. It must also concur with the new forms of knowledge production that knowledge-intensive companies are already familiar with (Nonaka & Takeuchi, 1995). At the end of this section we outline work in progress to implement this agenda at the School of Education at Fontys University for Professional Education.

The authors are of the opinion that we can no longer just rearrange and reapply the old way of thinking and doing things in education and ICT. Radical change must occur. Like the artist Prince, who as a result of a dispute with his record company changed his name to TAFKAP (The Artist Formerly Known As Prince), we favour approaches like TIFKAS (The Institution Formerly Known As School) to reflect upon what kind of education and school the pedagogic benchmarks for teacher education and training should fit. The terminology and thinking about TIFKAS also emerged at a seminar organised by the Inspectorate of Education. Each time schools with emerging practices in the use of ICT in education were visited, people who were the driving forces within the changes that were happening there emerged. They were named 'ICT eminences'. What most often characterised those eminences was a specific combination of knowledge, experience and expertise in teaching and technology, promoting change and developing enthusiasm for next steps. The Inspectorate invited some of these people for an experiment in 'building the ICT-rich school of the future'. It is interesting to note that most of the discussion centred on learning and learning environments, sometimes on teaching and teachers and only sporadically on ICT, although a lot of thought was given to the educational functions that ICT could deliver. The following list of characteristics resulted from reflection on the seminar results. In an ICT-rich institution:

- Learning is central and is seen as an integral process of thinking, producing, communicating, cooperating, and designing by learners and coaching, structuring, assisting, giving feedback and teaching by teachers and support staff.

- Learning must take place in a wide variety of subjects and for many types of intelligences. There is particular attention paid to digital literacy, information and research skills and competences.
- Learning processes are meaningful, challenging and constructive. Student choices – and thus their commitment – are of central importance. The institution provides for adaptive learning, guidance, and resources so that learning flows in a natural way.
- Learning is an integrated process. The start lies in experience (of the student and the faculty). From this starting point the participants choose projects, relate them to other innovations within the school, work with each other (students and faculty), work with external partners, researchers, and designers, etc.
- The timetable is similar to that in a work environment. Students (and faculty) work on projects with work contracts, work is concentrated in specific periods, cooperation is a necessity, feedback is vital, and integration of disciplines is required.
- The divisions between working and learning for both teacher and student dissolve. Learning and teaching should approximate the modern work organisation of knowledge development and management within the modern, knowledge-intensive society.
- The learning environment is transparent, open, connected, well-resourced, and flexible.
- The environment is (as) ICT rich (as the rest of the world). Students and faculty make use of a wide range of electronic and human connections, they have personalised access to human and electronic networks, and make use of tools such as PCs, laptops, handheld devices, digital cameras, digital sound, etc.
- Educational software is plentiful (content, electronic learning environments, e-portfolios, e-assessments).
- Learning tools and teaching aids are readily available and are integrated with each other. Examples of such tools are: visualisation tools, animations, simulations, knowledge networks, multiple representations, external representations, mind/concept maps, knowledge forums, search machines, knowbots, virtual environments (e.g. MUDs, MOOs [4]), chat rooms, e-whiteboards, tracking and reporting systems, teachable agents, applets, widgets, and generic tools.

Within TIFKAS, the divisions between productivity tools and mindtools (see Kirschner & Wopereis in this issue) also dissolve. Computer programs and applications that are ordinarily used as aids in the execution of work, make the users more productive when used in a challenging, innovative and reflective way, so it is not about the tool itself but about the way it is being used in expertise development. Examples are databases, spreadsheets, intentional information search engines, visualisation tools, multimedia publishing tools, live conversation environments, and computer conferences.

But apart from being a productivity tool, these same tools can also be used as an intellectual partner that enhances the cognitive powers of human beings during thinking, problem solving and learning. In this way these same applications become mindtools in that they facilitate meaningful professional thinking and working, helping users represent what they know as they transform information into knowledge. They are used to engage in, and facilitate, critical thinking and higher-order learning.

The ICT eminences mentioned could be seen as typical representatives of what Krogh et al (2000) call the 'knowledge activists'. Knowledge activists have three roles: catalysts of knowledge creation, coordinators of knowledge creation initiatives, and merchants of foresights. Knowledge activists are certainly not officers of knowledge control but they are activists, they do not determine but are well established in several micro-communities within their firm and within external networks. In our view there is an urgent need for more knowledge activists within our schools and schools of education that can play the role of knowledge translator. Nonaka & Takeuchi (1995) also present schemes of thought about knowledge creation. What seems essential in professional learning communities, real knowledge building in ICT-E, and making teaching a modern profession (Bereiter, 2002) is merging the many streams of knowledge creation (see also Engeström, 1999). In ICT-E this has to do with knowledge resulting from fundamental research, practical experiences being communicated between practitioners and the very important combination of the two types of knowledge creation. In Figure 1 we elaborate on these merging processes.

To From	Formal knowledge	Experiential knowledge
Formal knowledge	*Combination* Synthesise research, analysing concepts, formal meetings, formal networks	*Internalisation* Experimenting with concepts, learning by doing, through transfer to contexts
Experiential knowledge	*Externalisation* Codification of practices, report on practice and experiences, document	*Socialisation* Exchange experiences through observations, imitation, modelling, communities of learning practice

Figure 1. Merging types of knowledge.

Teacher education faculties in Dutch universities for professional education have recently had the opportunity to draw up new posts for professorswho have the task to lead and conduct applied research, development work and advanced teaching for undergraduate as well as higher-degree programmes. Fontys set up a chair for the educative functions of ICT in teacher training with specific attention to the use of ICT as a mindtool. This concept (Jonassen, 2000) is used to refer to a broad spectrum of ICT tools that can support teachers' analytic reasoning and thinking skills, students and pupils. Jonassen defines mindtools as:

> ... knowledge representation tools that use computer application programs such as databases, semantic networks, spreadsheets, expert systems, systems modelling tools, microworlds, intentional information engines, visualisation tools, multimedia publishing tools, live conversation environments and computer conferences to engage learners in critical thinking. The process of using these tools as formalisms for representing the ideas being learned in personal knowledge bases represents an alternative approach to integrating computers in schools. (p. 19)

The number of these types of tools is expanding every WWW year! (see van den Dool et al, 2003).[5] The same is the case with the number of publications in this field, also with respect to the use of mindtools in teacher training (Dabbagh, 2001).

The translation and diffusion from academic research to teaching practice is difficult all over the world and we cannot examine this problem in great depth. However, the ICT-E issue has specific characteristics (Bransford et al, 2000). It is very difficult for an individual school to catch up with the rapid developments in educational technology. This has also to do with the different modes of knowledge creation and knowledge diffusion within research and practice. Again a multiple challenge! Bringing together these worlds is one of the challenges for the newly created professorships within the universities for professional education.

To this end, the Fontys work programme on educative functions of ICT capitalises on the dynamic interaction between the worlds of research and the worlds of practice. This will be done by creating networks of students, teachers and schools to experiment with the use of mindtools in schools and colleges. There are already a lot of emerging practices that can be a source of inspiration (see Brush et al, 2001). These knowledge networks will at the same time be the organisational structures in which research and development projects are set up. They will also function as the cognitive and cultural habitats for teaching and learning the ICT-E topics in the initial teacher training programmes. This can be seen in Figure 2.

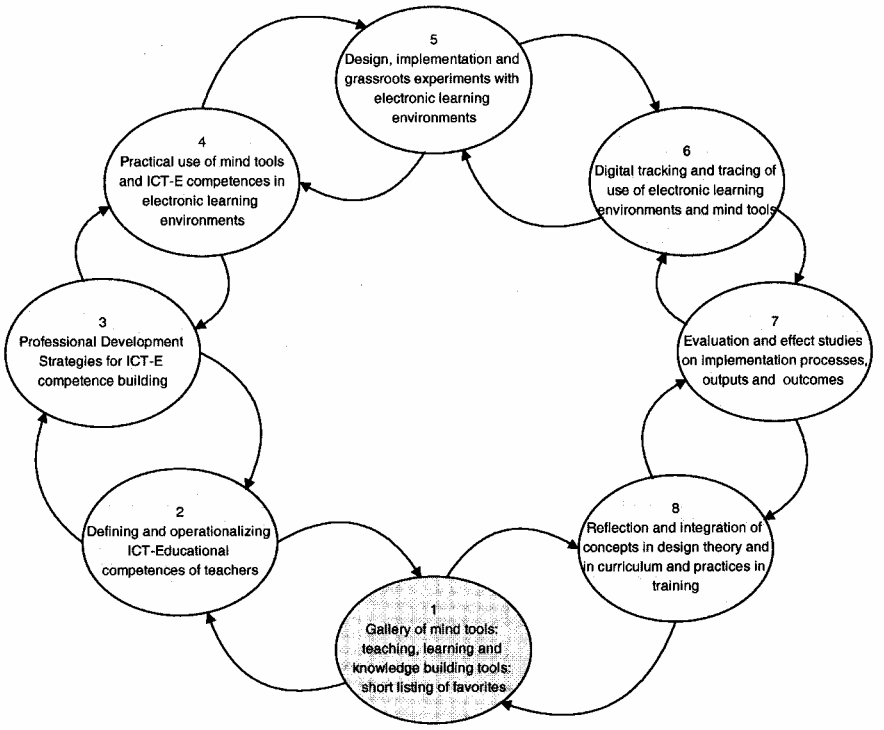

Figure 2. Agenda for Fontys work programme on educational functions of ICT.

Conclusion: ICT as a catalyst?

Whether ICT will function as a catalyst for pedagogical innovations and foster the quality of learning depends heavily on a combination of the product characteristics and the affordances and forcing functions used (Norman, 1988, 1998). The product characteristics, together with the learning and teaching contexts, define what type of educational functions can be accomplished.

If ICT is to become the intermediary between the different 'worlds of knowledge' needed for the new core competencies of learners and knowledge workers, and if it is to play a role in their knowledge-building competencies, then education must integrate ICT in ways different from making traditional expository teaching and learning more effective, efficient or satisfying. There is nothing wrong with an instructive, didactic, well-thought through expository lesson, but the future requires other or new individual cognitive activity from learners and workers. ICT must go beyond the status of a productivity tool and achieve the status of a mindtool.

We, as researchers and educators, view and try to use ICT as a catalyst for change and pedagogical innovation in education. Unfortunately, those who are continually paying lip-service to this idea of ICT as a catalyst are not faithful in their thinking to the real meaning of a catalyst. We often interpret it as a 'spot remover' for all kinds of educational stains and a 'crowbar' for forcing change. But a catalyst is actually a substance that speeds up a chemical reaction, itself remaining unaltered at the end of the reaction. In a more metaphoric sense, it is something that precipitates a process or event, without actually being involved in or changed by the consequences, as a free press is for an informed and responsible electorate. We are enamoured with the technology, but as an artefact. We adapt our education to fit the technology and adapt the technology in strange ways in our education. ICT functions as a catalyst in the real sense of the meaning when it assumes the role of unobtrusive agent in an already existing and functioning process. When the process of pedagogical innovation or organisational change is going on, then ICT can function as a catalyst.

Teachers need to integrate ICT competence into their core teaching competences and the educational system must integrate it into the heart of learning and teaching. What really counts at the end of the day is if teachers and learners feel that ICT tools are a 'normal' part of their competences and not an add-on, either in a positive or negative sense. To do this, teachers need to be professional learners and should therefore also function as researchers into their own practices. Thus, in their initial and continuing training, they must learn and work as co-researchers and co-designers of the technology and tools they want and need to use (see Figure 2). Expertise and competence development on the 'shop-floor' – in other words the integration of the educative functions of ICT in teachers' and learners' toolboxes – is a necessity for further integration of ICT into teaching and learning. The key to further developments is the dynamic interaction between the respective networks, communities and actors involved in the knowledge chains in the practice of education, the training of teachers, and in research and development agencies.

To meet the needs of the knowledge society, ICT has to be integrated within the three worlds (Bereiter, 2002) of knowledge that teachers and learners are confronted with. The two modes of knowledge production (the traditional RD&D [Research, Development and Diffusion] mode and the constructive mode of knowledge production [Gibbons et al, 1994]) in educational and social science research and development agencies should interact in a process catalysed by ICT. Gibbons et al make a distinction between two typical types of models within educational and learning theory and in the production thereof. The first (Mode 1) stresses the importance of instruction, structure in content, pedagogic models which influence the representation and formats of the content to teach, etc. These ideas are founded in behaviourism and cognitivism, instructional (design) theory, expository learning and other objectivist approaches. The second (Mode 2)

stresses the importance of cognitive activity on the part of the learner, of constructive working with information and knowledge, of discovery and exploratory learning. These ideas are founded more in the ideas behind constructivism (see Table II).

Mode 1 Expository learning: knowledge acquisition	Mode 2 Expertise development: knowledge building
Learning is based upon methodology and content conventions developed in education	Learning takes place in the context of the immediate application
Learning is organised in content domains, eventually based upon 'projects'	Knowledge and skills cannot be reduced to separate content domains
Learning is homogeneous and predictable in its methods and organisation	Learning is heterogeneous and idiosyncratic in its methods and organisation
The relationship between learning and society is sequential and indirect	Learning is related to other activities both with respect to time and direct impact
Quality criteria are based upon internal 'educational' standards	Quality is determined by the effect of what is learned on society

Table II. Modes of learning.

We want to stress that this is not a matter of preference for the left or right side of the table. Depending on the type of learners, subject and educational goals, a choice of pedagogical arrangement has to be made. In that context the question also has to be answered with regard to which educative functions ICT suffices in, in that specific situation (see also Sfard, 1998). Last but not least, there is a need for transdisciplinary approaches to tackle the forcing functions of ICT, that is, technological and cultural approaches in which the learners ('homo zapiens' – Veen, 2000) also are engaged as co-designers. To manage these dynamics could be the most important challenge for education that aspires to becoming a modern profession (Bereiter, 2002).

Notes

[1] ICT School Portraits by Dutch Inspectorate of Education http://www.onderwijsinspectie/ ictschoolportretten.nl

[2] School Portrait of the School of Education at the University for Professional Education of Amsterdam (in English): http://www.owinsp.nl

[3] Ehrman's triple challenge study: http://www.learner.org/edtech/distlearn/triplechallenge/

[4] MUD: Short for *Multi-user Dungeon* (or *Multi-User Dimension*), a cyberspace where users can take on an identity in the form of an *avatar* and interact with one another. Originally, MUDs tended to be adventure games played within enormous old castles with hidden rooms, trapdoors, exotic beasts, and magical items. Nowadays, the term is used more generically to refer to any cyberspace. MUDs are also known as *3-D worlds* and *chat worlds*.

MOO: Short for *Mud, Object Oriented,* a specific implementation of a *MUD* system developed by Stephen White. MOO is in the public domain and can be freely downloaded and executed.

[5] ObservETory on Educvational Technology: http://www.observETory.com

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