HUMAN TECHNOLOGY

An Interdisciplinary Journal on Humans in ICT Environments ISSN: 1795-6889

www.humantechnology.jyu.fi Volume 1 (2), October 2005, 157-175

ICT AND CURRICULUM CHANGE

Joke Voogt
Faculty of Behavioral Sciences
University of Twente
The Netherlands

Hans Pelgrum
Faculty of Behavioral Sciences
University of Twente
The Netherlands

Abstract: *The change towards the information society implies that many countries have to change their curricula, because students need to develop competencies that are not addressed in the traditional curricula. A case study approach was applied to examine curriculum changes in ICT-supported pedagogical practices from 28 countries. The analysis focused on curriculum content and goals of the ICT-supported pedagogical practices, how these aims were implemented in practice and which outcomes for students and teachers could be observed. The results showed that the curriculum content often was not new but rather was delivered in a different way. Many ICT-supported pedagogical practices strove to realize new goals important for lifelong learning in an information society. Content and goals were offered in curricular settings, often crossing the traditional boundaries of academic subjects. In many of the cases students worked on topics that were meaningful to them.*

Keywords: *information and communication technology (ICT), curriculum, pedagogy, primary education, secondary education.*

INTRODUCTION

The currently widely accepted rhetoric (e.g., European Commission, 2002; Organization for Economic Co-operation and Development [OECD], 2004) is that our society is changing from an industrial to an information society in which citizens need to be able to manage huge amounts of information that can be disclosed and processed with the help of information and communication technology (ICT). According to the European Commission, for instance, all citizens of the European Union should have the possibility to acquire so-called key skills, which include digital literacy and higher order skills such as teamwork, problem solving and project management (European Commission, 2002). Key skills are often referred to as lifelong learning competencies. According to the education ministers of OECD countries (OECD, 2004), the concept of lifelong learning covers all purposeful learning activity in a person's life. A major feature of the concept of lifelong learning is developing the capacity of "learning to learn." The lifelong learning approach anticipates a coping with the increased pace

URN:NBN:fi:jyu-2005356

of globalization and technological change (OECD, 2004). Many students that are about to start their school career eventually will get a job that does not yet exist. It is therefore often argued that nowadays young children need to develop lifelong learning competencies. Society—through formal and informal schooling—needs to create opportunities for their citizens to develop lifelong learning competencies. Voogt (2003) distinguishes a number of educational elements that are considered important in learning environments that foster the development of these competencies. In Table 1 these elements are organized in such a way that they show the characteristics of a pedagogical approach that is expected to be more dominant in an information society versus one that suits an industrial society. By using the words *less* and *more*, Table 1 also indicates that education nowadays is searching for a new balance for pedagogical approaches in schools.

One may argue that the implication of the change towards an information society is that many countries around the world have to move towards drastic changes in their curricula. The major reason is that students need to develop competencies that are not addressed currently in the traditional curricula. The design and implementation of curricula that are aimed at contributing to students' lifelong learning competencies is one of the major challenges of curriculum change and improvement efforts nowadays.

To understand the major problems in realizing curriculum change, several researchers (i.e., Goodlad, Klein & Tye, 1979; Travers & Westbury, 1989; Van den Akker, 1988, 2003) use an analytic framework of various curriculum representations: the intended, the implemented,

Table 1. Overview of pedagogy in the industrial versus the information society (adapted from Voogt & Odenthal, 1997; Wijnen, Zuylen, Mulders, & Delhoofen, 2000).

Aspect	Less (pedagogy in an industrial society)	More (pedagogy in the information society)
Active	Activities prescribed by teacher	Activities determined by learners
	Whole class instruction	Small groups
	Little variation in activities	Many different activities
	Pace determined by the program	Pace determined by learners
Collaborative	Individual	Working in teams
	Homogeneous groups	Heterogeneous groups
	Everyone for him/herself	Supporting each other
Creative	Reproductive learning	Productive learning
	Apply known solutions to problems	Find new solutions to problems
Integrative	No link between theory and practice	Integrating theory and practice
	Separate subjects	Relations between subjects
	Discipline-based	Thematic
	Individual teachers	Teams of teachers
Evaluative	Teacher – directed	Student – directed
	Summative	Diagnostic

and the attained. The competencies needed for citizens in the information society as outlined above can be considered the *intended curriculum*—the rationale and goals for learning. However, there may be a gap between the needs of the information society as expressed by policy makers and the way these needs are understood by schools and teachers. Moreover, what teachers and students actually do in the classroom—the *implemented curriculum*—may be quite different. The *attained curriculum* describes the learning outcomes of students as well as, when appropriate, the learning outcomes for teachers. It is obvious that these learning outcomes are particularly influenced by what has been taught—the implemented curriculum. One of the major challenges in realizing curriculum change is to create consistency and balance between these different curriculum representations.

ICT is believed be able to implement and facilitate the realization of the pedagogy that fits an information society (Dede, 2000; Office of Technology Assessment, 1995; Panel on Educational Technology, 1997). However, research shows that the implementation of ICT within a curriculum is a complex process. In the international study of Pelgrum & Anderson (1999) it was found that many countries experienced that, despite major investments, ICT implementation in education proceeded slower than expected. Although a rapid improvement in computers-per-student was observed, it appeared that the use of computers in subjects, except for computer literacy and computer science courses, was still marginal. A major problem is that educational software is often isolated and not integrated with the textbooks that many teachers use (Van den Akker, Keursten, & Plomp, 1992; Voogt, 2003). Moreover, many ICT applications are poorly attuned to the curriculum (Voogt, 2003). Also more practical reasons hinder the implementation of ICT. Cuban (2001), in a study on ICT use in the Silicon Valley region found that teachers hardly changed their teaching routines when using ICT. He found that big classes and 50-minute class periods hampered teachers' ability to use ICT in an innovative way. Olson (2000) argued that ICT often does not fit into the existing teaching culture and may even undermine the teacher's sense of efficacy. He found that teachers using technology therefore tend to domesticate applications so that they conform to prevalent practices. Although it is generally assumed that ICT has high potential for improving education, research consistently has had difficulty in providing convincing evidence on the impact of ICT on student performance. This is mainly due to the fact that the use of ICT often contributes to the mastery of complex cognitive skills. These types of skills cannot be determined by means of simple, standardized tests. Only recently, however, some major studies confirm the positive results of ICT on students' performance (e.g., the meta-analysis on the effects on student writing, Goldberg, Russell, & Cook, 2003; and the extensive literature review of Cox, Abott, Webb, Blakely, Beauchamp, & Rhodes, 2004).

These findings illustrate that many factors inhibit the implementation of ICT in the curriculum. In other words, there is a potential gap between the intended and the implemented and attained curricula.

The study presented in this article will focus on the relationship between ICT-supported pedagogical practices and changes in the curriculum. This study has been carried out as part of the SITES Module 2 research (see Kankaanranta, 2005, in this issue). Two phases of the study were conducted. Phase 1 had an exploratory character. In this phase a rationale for the selection of a subset of the ICT-supported innovative pedagogical practices, which were contained in the database of SITES Module 2, was developed and an initial analysis of the selected cases in comparison with all submitted cases was carried out. Based on this initial

analysis the balance of the study was conducted. Phase 2 consisted of an in-depth analysis of the cases selected in Phase 1. In both phases, the methodologies for data collection and analyses applied in SITES Module 2 have been used.

In this study the following research questions were addressed:

- What kind of changes in curriculum content and goals are associated with ICT-supported innovative pedagogical practices? (Intended curriculum).
- What are the learning experiences and assessment practices of these ICT-supported innovative pedagogical practices? (Implemented curriculum).
- What is the impact of the ICT-supported innovative pedagogical practices on students and teachers? (Attained curriculum).

An overarching question in the study was how ICT supports curriculum changes.

METHODS

Phase 1

The major aim of Phase 1 was to find a way for making an appropriate selection from the 174 case reports that were submitted for inclusion in SITES Module 2 by the participating countries.

Not all 174 cases submitted for SITES Module 2 were considered informative for a study on ICT and curriculum change. Initial coding of all cases was therefore used to make a first selection of cases that would be informative for further analysis. The initial coding of all cases was conducted by the International Coordination Committee and reviewed by the National Research Coordinators of SITES Module 2. The checklist that guided the initial coding contained two categories each within two broad indicators of ICT use within a curriculum: the first indicator related to the nature of the change within the curriculum, and the second assessed the nature of any value added as a result of implementing ICTs within the curriculum (see Figure 1). Changes of curriculum content, category a, would have occurred if a new subject had been introduced in the curriculum, such as information science or when new topics are added to or removed from the curricula of existing subjects. The change reflected by category b related to new learning goals that would have applied when the goals related to lifelong learning competencies had been introduced to the education process.

Does this case describe changes in the curriculum related to: *(tick all that apply)*

❒ a. Content
❒ b. Goals other than ICT skills and/or 'normal' subject related skills

Was there added value specifically claimed for ICT in the IPPUT*? *(tick all that apply)*

❒ c. ICT supports educational change/reform
❒ d. ICT supports a change in the curriculum

* IPPUT stands for Innovative Pedagogical Practice Using Technology

Figure 1. Indicators from the checklist used to select cases for Study 2.

An inspection of the data revealed that 91 cases reported either a change in curriculum content or in curriculum goals or both (see area A in Figure 2). By inference, this means that 83 cases did not contain references to curriculum change. In itself this is an interesting finding, as it means that in roughly half of the cases innovations were being practiced without major consequences for curriculum content and/or goals.

For the in-depth analysis of the research question about curriculum change and its related questions, the total of 91 cases needed to be further reduced. To generate a meaningful and manageable selection of cases for the in-depth analysis (Phase 2), the two additional categories from the checklist, (c) the added value of ICT for educational reform, and—more specifically—(d) the added value of ICT for curriculum change, were used within the original sample of 174. Educational change/reform referred to systemic change and is often broader than curriculum change only. According to the coding instructions this category could only be scored if the "added value" of ICT with regard to curriculum change or educational change/reform could be particularly related to the use of ICT in the case. There were 59 cases of the 174 that reported that ICT had added value in the change of education and/or the curriculum (see area B of Figure 2). It was expected that the intersection of the 91 cases that reported curriculum change on the one hand and the 59 cases that reported that ICT had added value for education and/or curriculum change on the other hand might lead to a selection of cases that potentially is very rich because it contained additional information on how ICT can support curriculum changes. The result was a group of 32 cases (see area C in Figure 2).

The next question was whether these 32 cases constituted a sufficient basis for doing an in-depth analysis. A first step in answering this question was to determine if this selection contained enough cases that could throw light on the research questions related to the attained curriculum (assessment, student outcomes and teacher outcomes). Table 2 shows that this was indeed the case. The 32 cases differed considerably from the other cases on assessment procedures, on the majority of indicators on student impact, and on a number of indicators on teacher impact. Therefore it was expected that the 32 cases indeed would provide information on outcomes and assessment practices, and therefore probably could serve as a good basis for analyzing the research questions in this chapter.

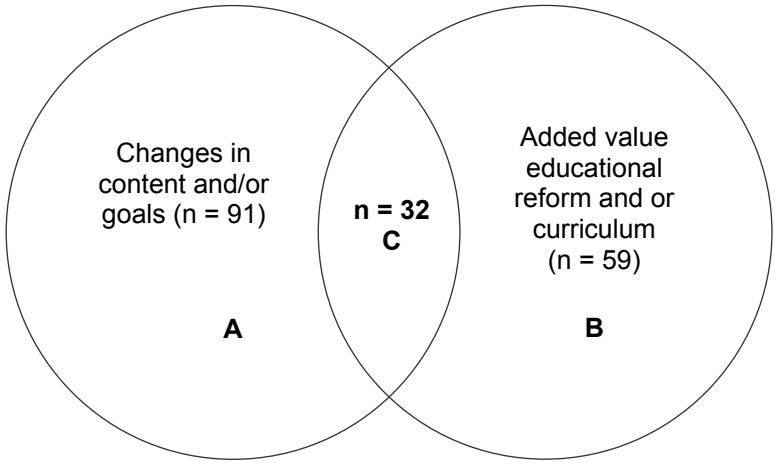

Figure 2. Venn diagram of the process for case selection.

Table 2. Comparison of selected and non-selected cases on curriculum change, assessment, outcomes and added value (based on initial coding).

Questions	All cases (n=174)	All non-selected cases (n=142)	Selected cases (n=32)
Changes in the curriculum related to			
Content	27.0	19.7	59.1
Goals	37.4	29.6	71.9
Organization	68.4	67.6	71.9
Time	36.2	35.2	40.6
Alternative assessment procedures	60.3	42.3	71.9
Impacts on teachers in terms of			
New pedagogical skills	56.9	54.9	65.6
ICT skills	63.2	63.4	62.5
Collaborative skills	35.1	30.3	56.3
Positive attitudes	21.3	19.0	31.3
Negative outcome	7.5	5.6	15.6
Impacts on students in terms of			
Subject matter knowledge	62.6	63.4	59.4
ICT skills	75.3	73.2	84.4
Communication skills	39.7	37.3	50.0
Problem solving skills	19.0	16.2	31.3
Information handling skills	28.7	26.1	40.6
Team-/ collaborative skills	62.6	59.9	75.0
Metacognitive skills	38.5	38.0	40.6
Positive attitudes	68.4	68.3	68.8
Added value ICT			
Added value for curriculum change	16.1	16.2	62.5
Added value for educational reform	24.7	8.5	50.0

A second step was to find a solution to the problem that the in-depth selection might lead to conclusions that are biased as a result of very specific characteristics of the selected cases, such as specific use of ICT. The solution ultimately found was a compromise between manageability and bias prevention.

For this reason a subset of the cases that did not meet the criteria for selection was examined. We analyzed these cases in the following ways: (a) For the cases that did not contain indications of curriculum changes in content or new goals, we sought the potential reasons for this lack of change, and (b) If the reported cases of curriculum changes (in content or new goals) were not associated with changes in ICT use, what might be reasons that ICT was not perceived as having added value in supporting these changes?

With regard to the first item, we examined 23 of the cases that did not contain indications of curriculum change. A first observation from this examination is that, for most of these

cases, explicit statements were made about the lack of curriculum content change. Often it was stated that the content of the curriculum was the same as before. The reasons given were primarily either (a) the innovation concerned only pedagogical change, or (b) the innovation took place as an add-on to the existing curricula (e.g., extracurricular, optional, elective, etc.). It was interesting to observe that in a vast majority of these cases the innovative practice was perceived as being beneficial for creating more student-centered pedagogical approaches. Also, a substantial number of cases contained explicit statements that ICT was indispensable for running the innovation. A conclusion that emerges from the data is that new kinds of curricular goals and content (such as in information management skills and collaboration skills) appear to be unanticipated effects of the innovation, rather than new goals from the start.

With regard to the second question, we examined 28 of the cases where curriculum change occurred but was not associated with the added value of ICT. In many of these cases, however, it was explicitly stated that ICT was indispensable for implementing the innovative practice. The contribution of ICT was praised in terms of its support for pedagogy rather than curriculum change.

Phase 2

The 32 cases that were selected in the first phase came from 15 countries. These cases were analyzed in-depth. The analytical framework used the curriculum representations that were distinguished above, namely the intended, implemented and attained curricula. For each curriculum representation, the following dimensions have been included in the analysis.

- Intended curriculum: changes in content and goals of the curriculum.
- Implemented curriculum: teacher and student activities; changes in curriculum organization; changes in assessment practices.
- Attained curriculum: teacher and student outcomes.

And finally we focused on the added value ICT had for these dimensions.

The 32 cases were coded on the basis of a code list that was elaborated by the International Coordination Centre. From this code list a selection of codes considered appropriate for answering the research questions was used. After having coded a case the research questions were briefly answered for that particular case and supporting quotations were selected. Examples from codes (and intersections of two codes) and the code results are presented in Figure 3.

RESULTS

Three Patterns Emerged

A general observation from the analysis was that the terminology used in the case reports to describe changes in curriculum content and goals, teacher and student activities, assessment practices, and outcomes appeared to be quite similar in primary, lower and upper secondary education. However, only in the cases in upper secondary education were the goals more often expressed in terms of further studies or career perspective.

Examples from the code list
4.2.1 Content-related goals
4.2.2 Goals other than ICT or subject-related skills
4.2.5 ICT related goals
4.2.6 Change in content
4.2.7 Change in goals

Examples from codes attached to a quotation in the case description
From the case Mathematics learning with the interactive toolkit (Philippines – see below)
Codes: [4.2.1 Content-related goals] [4.2.2 Goals other than ICT or subject-related skills]
As a technology for learning, the innovation is a student-centred educational programme designed ideally for self-paced learning, though the goal remains the same for all types of learners: to enhance the development of critical thinking skills through hands-on investigation, in-depth verification, exploration, and discovery of science concepts and processes.

From the case ICT a bridge to communication (Israel – see below)
Codes: [7.4.5 ICT supports ed change/reform]
Most of the evidence supports the claim that technology is a strong catalyst for innovations and improvements in education, especially when the Internet is involved. The school staff does not see itself functioning adequately without ICT. ICT is grasped as a means of developing living skills and adapting to the modern world, for teachers as well as for students. When the teachers were asked what would happen had the computers been taken away from the school, their responses ranged from prospects for deep fear of lack of satisfaction at work, to retreat and stagnation. There was even a sort of personalized reference to ICT, as one of the teachers worded it well: "Just not that. We have gotten used to them, and we became very attached to them. We will miss them very much. It will set us a few steps backwards. "There is no doubt that ICT triggered the innovation and pushed the school forward, raising self-esteem of teachers, students and parents within the school. According to one of the parents interviewed, who holds a senior position in the ministry of education, "there is no precedent for an integrative school exhibiting such high achievements. I have no doubt that the ICT had a crucial influence."

Figure 3. Examples from codes and quotations from case descriptions.

Although the selected cases all had indications of curriculum change, one might expect that quite large differences exist between them in terms of the nature of the changes. For instance there may be relatively small changes in content of a single or a few subjects (involving a limited number of actors in the school) as compared to relatively large changes with a school-wide orientation and related implications. From the first overview of results it appeared that there were indeed strong indications for the existence of this variation. A major distinction that appeared was between school-wide innovations (involving multiple subjects) and innovations that were more limited in scope. Regarding the latter, a further distinction could be made as it showed that a number of cases were oriented on single discipline-based subjects, while others seemed to be of a cross-curricular nature, using themes to organize the curriculum instead of academic disciplines. Based on these observations the following distinctions were made:

Single-subject Curricular Focus: The ICT-supported innovative pedagogical practices were situated within discipline-based subjects. ICT was primarily used to improve understanding subject matter content and concepts. An example of the Single-subject

Curricular Focus is about learning mathematics in a secondary school in the Philippines (mathematics learning with the interactive toolkit):

> *The interactive toolkit for mathematics (ITM) supported 9th grade students to learn concepts in basic analytic geometry. ITM provided students with a new approach to create simple geometric figures, explore the relationships among quantities represented in the figures, and make conjectures about these properties. The use of the ITM in the innovation was aimed at developing critical thinking in mathematics and made it easier for students to understand the mathematical concepts through self-exploratory activities. In this way more emphasis could be given to the depth and breadth of the course content. The curriculum standards were correspondingly enriched.*

Thematic Curricular Focus: The ICT-supported innovative pedagogical practices were of a cross-curricular nature. Curriculum content was offered through themes and ICT was used to facilitate the implementation of lifelong learning goals. An example of the Thematic Curricular Focus is from a primary school in Israel (ICT a bridge to communication):

> *Skills and knowledge acquired in the ICT projects in this primary school were implemented in other learning and social situations. Students worked 2 hours per week on each project: one hour in the classroom focusing on skills such as planning, writing texts, editing a report, managing a virtual discussion etc. The second lesson was held in the computer lab, where the students learned to use ICT for their assignments. Each project had its own web pages which students and teachers used for communication and for presentation of results. The school considered ICT projects as a major means of realizing independent learners.*

School-wide Curricular Focus: The ICT-supported innovative pedagogical practices were integrated throughout the school curriculum. ICT facilitated the realization of the school's vision on teaching and learning. An example of the School-wide Curricular Focus is from an Australian school (Multimedia development tools and authentic tasks):

> *The technology rich environment was seen as a vehicle to achieve innovative approaches to teaching and learning at this primary school. Students had to make critical decisions about their own learning. The school instituted systems that formally recognize the ability of students to play a leading role in the teaching of others, not necessarily restricted to ICT. A predominant application of ICT was the development of multimedia products by students. The innovation is a representation of the school's philosophy and beliefs about how students learn.*

Table 3 shows the distribution of the cases across the three patterns. A cross-case analysis of the three patterns was conducted using the curriculum dimensions that were presented in the methods section.

Table 3. Country origin of cases to education level and Curricular Focus.

	Single-subject Focus	Thematic Focus	School-wide Focus
Elementary education	*China Hong Kong* (Chinese punctuation; Cyber art project)	*Italy* (Smoke signals) *France* (Vendee globe junior; Integration of ICT in learning) *Israel* (ICT a bridge to communication) *Germany* (Media competence)	*Australia* (Multimedia development tools and authentic tasks; Constructivist teaching with ICT) *Norway* (Integrated use of ICT) *Israel* (School of the future)
Lower secondary education	*South Korea* (Learning environment for science) *the Philippines* (Mathematics learning with the interactive toolkit) *Norway* (The use of web-based integrated science environment in the subject science and environment)	*Australia* (Cinderella is just in time) *Germany* (Media competence)	*Singapore* (Project I) *Germany* (Laptops in grade 8) *Norway* (Visual communication)
Upper secondary education	*Germany* (Self- directed learning in mathematics, Using ICT for information management and design purposes in arts education) *the Netherlands* (Collaborative learning in animal husbandry) *the Philippines* (Micro-computer based science laboratory) *Israel* (Center for leadership & excellence) *Finland* (Web development course)	*France* (Satellite images) *South Africa* (Theme day) *Czech Republic* (Project region; School library as multimedia center) *Germany* (Personality development) *Israel* (The web learning center - also lower secondary)	*USA* (Future high school)

The Intended Curriculum

The results of the in-depth analysis showed that the ICT-supported innovative pedagogical practices did not concentrate so much on new content but were rather aiming at the realization of lifelong learning competencies within the existing content, or at offering existing curriculum content in a different way. The focus of the curriculum changes that took place

differed among the three patterns. The Single-subject Curricular Focus particularly focused on improvement of the teaching of content and concepts. The change did not typically refer to new curriculum content, but to a more in-depth coverage of content. Important skills that were mentioned were problem solving and critical thinking. The goals of the innovations concerned the improvement of understanding by students of the subject matter and the need to develop higher order thinking and reasoning skills. A typical example of the innovations in this pattern is a case from the Philippines. In this case ICT was used in a ninth grade math class in order to facilitate the learning of concepts in basic analytic geometry. The use of ICT made it possible to easily change variables and to show the different graphs, which then could be compared. In this way more emphasis could be given to the depth and breadth of the course content. A better understanding of curriculum content was also the main reason for the innovation of the eighth grade science curriculum in a case from South Korea. The traditional approach, where the teacher presented research results, was replaced by a curriculum in which students conducted lab experiments and simulations and wrote up their results.

On the other hand, in the Thematic Curricular Focus, the aim of the innovations was not so much focused on change in curriculum content, but rather on new goals that were considered important for the information society. The innovative technology-based practices in this pattern often referred to lifelong learning competencies. For instance, the Israeli primary school that implemented ICT-based projects considered these projects as a major means of developing independent learning skills that are seen as essential for students' adjustment to the information society. In order to realize these goals, curriculum content had to be delivered in a different way and, therefore, cross-curricular and thematic approaches to the curriculum were adopted.

In the School-wide Curricular Focus the realization of new goals was an important aim, with a strong focus on realizing education that fosters student responsibility for their own learning. These schools focused on in-depth and independent learning. A good example is the Australian primary school and multimedia development tools. In this case the potential of ICT was used to realize curriculum goals that focused on (a) changing and improving the nature and quality of thinking and problem-solving processes, (b) supporting students in learning more about themselves and their world, in taking action, and in making a difference locally and globally, (c) enhancing the power and effectiveness of the message being communicated or the position argued, (d) improving students' critical engagement with and analysis of information being created and explored, (e) improving literacy and numeracy outcomes, (f) improving the independent and collaborative skills of all learners, and (g) supporting students in learning how to learn. In particular, the cases in the School-wide Curricular Focus expressed a clear relation between the innovative practice and the vision of the school on teaching and learning. In the School-wide Curriculum Focus pattern, curriculum content was offered in a cross-curricular way and embedded in authentic contexts.

Learning about ICT could have been mentioned in the cases as new curriculum content that was offered. Yet, only a very few cases, at the level of upper secondary education, dealt with learning about ICT. In most innovative practices in this study, learning about ICT was not mentioned as new content or as a new subject that was offered. However, the acquisition of ICT skills was considered important, but it appeared that these skills were not learned isolated from its context, but rather were integrated in the learning of other skills, such as communication skills and information handling skills. An example is the German case where fifth grade students had to use ICT for interdisciplinary projects. As was written in the case

report, "*One of the objectives is to prepare students for lifelong learning and to develop their competence in team-working and their social skills."*

The Implemented Curriculum

In order to realize the curriculum goals, learning environments for students were created. In all three patterns these learning environments appeared to be quite similar: Students created products or carried out a research project. Students collaborated during their project or research work and searched for information. In the innovative practices in the Thematic and School-wide Curricular Focuses students also published or presented results of their project work and were involved in self- or peer assessment. Particularly in the School-wide Curricular Focus, students picked their own tasks. For an overview, see Table 4.

Teachers advised and guided students, while simultaneously providing structure and keeping track of students' progress. In the Single-subject Curricular Focus, teachers also mediated content and prepared (sometimes ICT-based) instructional materials for students. This latter activity was also typical for teachers in the Thematic Curricular Focus. In the Philippine math case, for instance, the teacher started the lesson with a short lecture, which included goal setting, a review of related concepts and the unlocking of difficulties. To realize the organizational challenges, the collaboration between teachers was quite intensive in the School-wide Curricular Focus. Such teacher collaboration was encouraged and facilitated by the schools. For instance, in an Australian primary school, teachers of a particular year level were provided with non-instructional time (see Table 5).

Despite the similarity in learning environments, the embedding of innovative practices in the school curriculum was very different. In the School-wide Curricular Focus, students participated in the innovative practice throughout the whole school day. For these students the concept "school" was identical with the innovative practice. In the other two patterns the time that was allocated to the innovative practice varied a lot and was sometimes difficult to estimate. There were cases that were completely integrated in a subject that ran throughout the year. Other innovations took two classroom periods throughout the year for all grade levels. In some cases a specific period in the school year was reserved for the innovative practice, varying from a two-week block to a single-day project held four times. Because of the variation

Table 4. Overview of student activities per Curricular Focus (in % and absolute).

Student activities	Single-subject (n = 11)		Thematic (n=13)		School-wide (n=8)	
Searching for information	63.6	(7)	76.9	(10)	100.0	(8)
Publish/present results	45.5	(5)	76.9	(10)	87.5	(7)
Problem solving tasks	54.5	(6)	23.1	(3)	62.5	(5)
Picked own tasks	27.3	(3)	46.2	(6)	75.0	(6)
Collaboration	90.9	(10)	61.5	(8)	87.5	(7)
Self- or peer assessment	27.3	(3)	53.8	(7)	75.0	(6)

Table 5. Overview of teacher activities per Curricular Focus (in % and absolute).

Teacher Activities	Single-subject (n=11)		Thematic (n=13)		School-wide (n=8)	
Lecture	54.5	(6)	0.0	(0)	37.5	(3)
Advise/ guide students	90.9	(10)	92.3	(12)	100.0	(8)
Create structure	90.9	(10)	92.3	(12)	100.0	(8)
Design/ prepare instructional materials	81.8	(9)	72.7	(8)	54.5	(6)
Monitor/ assess student progress	72.7	(8)	69.2	(9)	87.5	(7)
Collaborate with colleagues	54.5	(8)	53.8	(7)	100.0	(8)

in the duration of the innovations in the Single-subject Curricular Focus and the Thematic Curricular Focus it is more difficult to grasp the impact of the innovations on students, teachers and the school as a whole.

In three cases of the School-wide Curricular Focus the school interior was changed in order to implement the changes. For instance, in the Israeli "school of the future" a group of 75 students was taught by two to three teachers. Each group had their own "home" that was the size of two classrooms. Each home contained three study environments: an open space teaching area, a computer gallery, and a mini-auditorium.

Regarding assessment, three patterns of evaluation were observed. In about 30% of the cases it was explicitly stated that there were no changes in assessment practices. In the Single-subject Curricular Focus and the Thematic Curricular Focus, changes in the assessment practices implied that more emphasis was placed on formative assessment instead of summative assessment only. In many of the cases this implied that teachers gave feedback to students about their progress. Also with regard to summative assessment, changes could be observed. For instance the evaluation of students' products was an important element of summative assessment, instead of only paper-and-pencil tests. Teachers often felt that these new assessment practices were still in an initial stage.

In the School-wide Curricular Focus new assessment systems were adopted, in which formative and summative assessment were integrated. In these assessment practices students and teachers were actively involved. For instance, in an Australian primary school, students developed and agreed upon rubrics for assessing results of a science project. Students in a Norwegian primary school had to write a logbook at the end of each week in which they described how they worked, what subjects they worked on, and what they could do better. ICT did not yet support assessment practices a lot but, when it did, particularly electronic portfolios were used and seen as promising.

The Attained Curriculum

With regard to the findings concerning student and teacher outcomes a word of caution is in place. First of all, in only a very few case reports was reference made to objective data as evidence for the outcomes. When objective evidence was presented, it mostly was related to subject matter related outcomes. In most case reports, however, the impact of the innovative

practice on teachers and students was described in terms of perceived outcomes, based on opinions from teachers, students, the school principal, or parents. Besides, in quite a number of case reports, the researchers inferred the impact of the innovative practices on student and teachers from their observations and interviews. Often we felt that these inferences were based on the fact that students or teachers carried out specific activities, rather than on concrete, demonstrated outcomes. Despite these remarks, the cases provide us with indications about the kind of outcomes that could be expected from the innovative practices.

First we will focus on outcomes for students. A general finding throughout the three patterns was that students were very positive about the innovations. Students were motivated for the innovation and the innovation improved their self-esteem. In a majority of the cases a positive attitude towards learning and school was reported. Table 6 presents an overview of the findings.

From the analysis we may infer that the acquisition of ICT skills was an important student outcome in all three patterns. It was unexpected that the acquisition of ICT skills appeared also important in the Single-subject Curricular Focus, because these skills were not part of the goals that were pursued. It is noteworthy that in all three patterns ICT skills were not learned separate from the context in which the students needed these skills.

The acquisition of collaborative skills was important in the Thematic and School-wide Curricular Focuses. It must be noted that the acquisition of communication skills was often mentioned in relation to the acquisition of collaborative skills. For instance, one of the students in the Czech case, where upper secondary school students had to collaborate in designing a website for villages in the region, said: "*A student has much more responsibility working on this project. We have to learn to communicate with different people. I like the fact that I can choose the way of work that suits me best*."

Subject matter knowledge was an important student outcome in the Single-subject Curricular Focus. This was expected because the reason for using ICT was to improve the teaching of content. The importance of the acquisition of information handling skills in the Thematic Curricular Focus was also not unexpected, because information handling was seen as an important skill for lifelong learning. One of the students from the German media class very well expressed the importance of information handling skills *"I find it better. You can really*

Table 6. Overview of student outcomes per Curricular Focus (in % and absolute).

Student outcomes *Acquisition of*	**Single-subject (n=11)**		**Thematic (n=13)**		**School-wide (n = 8)**	
New subject matter	90.9	(10)	46.2	(6)	37.5	(3)
ICT skills	90.9	(10)	76.9	(10)	87.5	(7)
Communication skills	9.1	(1)	69.2	(9)	75.0	(6)
Problem-solving skills	27.3	(3)	30.8	(4)	37.5	(3)
Information-handling skills	18.2	(2)	61.5	(8)	37.5	(3)
Team/ collaborative skills	45.5	(5)	92.3	(12)	87.5	(7)
Meta cognitive skills	45.5	(5)	30.8	(4)	50.0	(4)
Positive attitudes learning/school	63.6	(7)	76.9	(10)	62.5	(5)

form your own opinion. If you have a book, you have to believe what is written in the book. But when I have five different pieces of information and three are the same but two differ, then I can quietly read through them all and make up my own mind about what to believe and what not to believe." The emphasis on students' responsibility for their learning process, an important aim of the innovative practices in the School-wide Curricular Focus, raised expectations about the acquisition of metacognitive skills in this pattern. In the innovative practices in this pattern, the metacognitive skills in student outcome were only mentioned in half of the cases. Maybe the acquisition of metacognitive skills was taken for granted. We found that the acquisition of metacognitive skills was also mentioned in nearly half of the cases in the innovative practices of the Single-subject Curricular Focus. For example, in the Korean case report on a learning environment for science, the national research coordinator wrote, "*The biggest difference that the innovative practice brought about was that students changed from receivers who simply swallow presented materials to constructors who create their personal knowledge."* Apparently students and teachers experienced the acquisition of these skills as a positive, but unexpected, side effect of the innovative practice.

The innovative practices did not only have impact on students, but also on teachers. A general outcome for teachers in all three patterns was the development of a positive attitude towards the innovative practice, particularly because of the recognition the teachers got from colleagues in the school. The development of pedagogical skills was an important teacher outcome in many innovative practices in all three patterns, but appeared particularly important in the innovative practices that were part of the Single-subject Curricular Focus. The acquisition of ICT skills appeared to be an important outcome for teachers in the Single-subject and School-wide Curriculum Focuses, often because of having to learn new applications. A side observation was that the fast development of technology was also a concern of quite a number of the teachers involved in the cases. They felt that continuous ICT training was necessary to keep up with the developments. For an overview, see Table 7.

The acquisition of collaborative skills was seen as an important outcome in the Thematic Curricular Focus and the School-wide Curricular Focus. Particularly in the innovative practices of the School-wide Curricular Focus, the development of collaborative skills was explicitly related to formal and informal strategies for professional development that the school had incorporated in order to support the implementation of the innovation.

Added Value of ICT

The innovative practices showed how ICT was used to contribute to curriculum change and educational reform. We found that productivity software and web browsers were used in the

Table 7. Overview of teacher outcomes per Curricular Focus (in % and absolute).

Teacher outcomes ***Acquisition of***	**Single-subject (n=11)**		**Thematic (n=13)**		**School-wide (n=8)**	
Pedagogical skills	81.8	(9)	53.8	(7)	62.5	(5)
ICT skills	72.7	(8)	46.2	(6)	75.0	(6)
Collaborative outcomes	36.4	(4)	61.5	(8)	75.0	(6)

majority of the cases that were analyzed for this study. In addition quite a number of the innovations used e-mail as a means of communication. These widely spread ICT applications were used as one of the means to relate the curriculum to the real world: students could prepare for presentations that have a professional outlook, search for information that is up-to date, and communicate with others (sometimes, but not yet very often) outside the school. We also found that in the Single-subject Curricular Focus the innovative practices used specific software (particularly in math and science) or that a special Website was created. In a number of these innovations, ICT facilitated guided, reflective inquiry, whereby modeling and visualization were used as powerful means to enhance learning.

From the way the cases were selected we could expect a clear role for ICT in supporting curriculum change. Our analysis showed that this role differed to some extent among the three patterns that we distinguished. In the Single-subject Curricular Focus, ICT supported a more in-depth coverage of curriculum content that seemed to foster student understanding of subject matter. In this case one may argue that ICT particularly improved the existing curriculum. In the two other patterns the added value of ICT was more explicitly related to educational reform. In the Thematic Curricular Focus this reform was related to changes in our society: Students should master new goals to be prepared for the information society. In the School-wide Curricular Focus the acquisition of new goals were clearly related to the responsibility of students for their own learning. Hence the educational reform in the innovative practices in this pattern accentuated somewhat more a new view on teaching and learning.

We found quite often that, in the cases in our selection, claims were made in the submitted reports about ICT having added value for student outcomes. Apparently ICT was indispensable for the acquisition of the new goals. As has been said above, a result of the ICT-supported innovative pedagogical practices was that teachers acquired ICT skills, hence ICT had also added value for teacher outcomes. Not many innovative practices in our selection reported about the added value of ICT for assessment practices.

DISCUSSION

This article analyzed the innovative practices of a select number of school report cases regarding ICT use and curriculum change. We showed through this study that the curriculum content offered in most cases was not new, but rather simply delivered in a different way. Often curriculum content was offered in curricular settings, crossing the traditional boundaries of academic subjects. Moreover, in many of the cases, students worked on topics that were meaningful to them because the topics were related to real life, including the students' own experiences. Many of the innovative practices aimed at the realization of new goals that were related to skills that were considered important for lifelong learning in an information society. In addition we noticed that assessment practices were starting to change in many of the innovative practices. Particularly formative (that is, process-oriented) assessment was considered important. From these findings we may conclude that quite a number of the features of these innovative curricula reflect elements of an emerging pedagogy (see also Table 1). However, some of the characteristics that were mentioned in the literature were hardly found in the innovative practices. For instance in our selection of cases we did not find many innovative practices where students and teachers collaborated with outside

actors. Apparently the boundaries between school and the outside world did not change yet in many of these ICT-supported innovative pedagogical practices. Also we did not find many cases in our selection where ICT was used to make learning independent from time and place.

Particularly those innovative practices that were related to Single-subject ICT were used to enhance learning of content and concepts that were important in academic subjects. These practices particularly focused on improving existing education. We found that these innovative practices, as far as the aims and rational for the innovation are concerned (the intended curriculum), did not explicitly refer to notions concerning the information society or new visions for teaching and learning. However we also found that, in these innovative practices, the learning environments provided often promoted skills such as collaborative and metacognitive skills that are considered important for lifelong learning.

An important finding was that ICT skills were not taught in isolation but were part of more complex skills, such as information handling, collaboration, and communication, and were embedded in an authentic context. In particular, these more complex skills were seen as important competencies that students gained from the innovative practice. Such a finding could influence discussions about the place of "computer literacy" as a separate subject in the school curriculum. It seems that the basic knowledge and skills of ICTs that are taught in many computer literacy courses are considered important, but not enough to prepare students for the information society. The results of this study suggest that the curriculum should go beyond those basic knowledge and skills and embed ICT literacy within more complex skills such as information handling, communication, and collaboration. Moreover the results also suggest integrating these skills into meaningful content.

In our analysis of curriculum-related changes, we distinguished three patterns: the Single-subject Curricular Focus, the Thematic Curricular Focus, and the School-wide Curricular Focus. Each pattern was characterized in terms of focus (academic subjects, cross-curricular, or school-wide) and the perceived added value of ICT for the curriculum, either to improve teaching existing content, to facilitate the learning of new goals, or to facilitate a new vision on teaching and learning. Despite differences in the goals and ambitions that were pursued (the intended curriculum) in the various schools, we also found in general that the innovative practices were rather similar in the learning environments they provided to the students (the implemented curriculum) and the outcomes realized for teachers and students (the attained curriculum). Students worked collaboratively on projects, they gained positive attitudes, and they acquired ICT skills and developed collaborative skills.

When reflecting on the curriculum changes that were found in a substantial number of the innovations one may argue that these changes were fairly marginal, particularly when the share of these changes in the whole school curriculum is taken into account. After all, only in a relatively small number of the cases the school curriculum as a whole changed (we called this the School-wide Curricular Focus). On the other hand one must realize that many SITES Module 2 cases were grass root initiatives that had to operate within the context of state or national curriculum and examination requirements. Although these curriculum and examination requirements may vary in the extent to which they leave room to the innovative practices, one may assume that in many situations the innovations were limited in their possibilities for curriculum change, particularly when change in content is at stake (see also OECD, 2001). This observation questions the role of governments in promoting change. If it is indeed true that countries around the world have to move to drastic curricular changes, then

governments should provide more room for such change, which implies that curriculum and examination requirements need to be reviewed and probably adapted.

REFERENCES

Cox, M., Abbott, C., Webb, M., Blakely, B., Beauchamp, T. & Rhodes, V. (2004). *A review of the literature relating to ICT and attainment.* Retrieved September 6, 2004, from http://www.becta.org.uk

Cuban, L. (2001). *Oversold and underused: Computers in the classroom.* Cambridge, MA: Harvard University Press.

Dede, C. (2000). Emerging influences of information technology on school curriculum. *Journal of Curriculum Studies*, *32*, 281-303.

European Commission. (2002). *eEurope 2005: An information society for all*. Brussels, Belgium: European Commission.

Goldberg, A., Russell, M., & Cook, A. (2003). The effect of computers on student writing: A meta-analysis of studies from 1992–2002. *The Journal of Technology, Learning and Assessment, 2*(1). Retrieved January 20, 2004, from http://www.bc.edu/research/intasc/jtla.html

Goodlad, J. I., Klein, F., & Tye, K. A. (1979). The domains of curriculum and their study. In J.I. Goodlad and Associates (Eds.), *Curriculum inquiry: The study of curriculum practice* (pp. 43-76). New York: McGraw Hill.

Kankaanranta, M. (2005). International perspectives on the pedagogically innovative uses of technology. *Human Technology*, *1*, 111-116.

Office of Technology Assessment. (1995). *Teachers and technology*. Washington, DC: U.S. Government Printing Office.

Olson, J. (2000). Trojan horse or teacher's pet? Computer and the culture of the school. *Journal of Curriculum Studies*, *32,* 1-8.

Organization for Economic Co-operation and Development [OECD]. (2001). *Learning to change: ICT in schools*. Paris: OECD.

Organization for Economic Co-operation and Development [OECD]. (2004, February). Policy Brief: Lifelong learning. *Observer*, 1-8. Retrieved June 30, 2005, from http://www.oecd.org/dataoecd/17/11/29478789.pdf

Panel on Educational Technology: President's committee of advisors on science and technology. (1997) *Report to the president on the use of technology to strengthen K-12 education in the United States* (March, 1997). Washington, DC: U.S. Government Printing Office.

Pelgrum, W. J., & Anderson, R. A. (Eds.). (1999). *ICT and the emerging paradigm for life long learning: A worldwide educational assessment of infrastructure, goals and practices.* Amsterdam: International Association for the Evaluation of Educational Achievement.

Travers, K. J., & Westbury, I. (1989). *The IEA study of mathematics I: Analysis of mathematics curricula*. Oxford, UK: Pergamon Press.

Van den Akker, J. J. H. (1988). The teacher as learner in curriculum implementation. *Journal of Curriculum Studies*, *20*, 47-55.

Van den Akker, J. (2003). Curriculum perspectives: An introduction. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum landscapes and trends* (pp. 1-10). Dordrecht, the Netherlands: Kluwer.

Van den Akker, J., Keursten, P., & Plomp, T. (1992). The integration of computer use in education. *International Journal of Educational Research*, *17*, 65-76.

Voogt, J. (2003). Consequences of ICT for aims, contents, processes and environments of learning. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum landscapes and trends* (pp. 217-236). Dordrecht, the Netherlands: Kluwer.

Voogt, J. M. & Odenthal L. E. (1997*). Emergent practices geportretteerd: Conceptueel raamwerk.*[A portrait of emerging practices: A conceptual framework]. Enschede, the Netherlands: Universiteit Twente.

Wijnen, W. H. F. W., Zuylen, J. G. G., Mulders, D. J. W. M., & Delhoofen, P. J. W. M. (2000). *Naar een nieuw evenwicht: uitwerkingen van de zes hoofdkenmerken van ontwerpgericht onderwijs*. [Towards a new balance: Elaborations of the six core characteristics of design-oriented education]. *OGO-brochure nr. 2*. Eindhoven, the Netherlands: Onderwijs Service Centrum Technische Universiteit Eindhoven.

All correspondence should be addressed to:
Joke Voogt
Department of Curriculum, Faculty of Behavioral Sciences
University of Twente
P.O. Box 217
7500 AE Enschede
The Netherlands
j.m.voogt@utwente.nl

Human Technology: An Interdisciplinary Journal on Humans in ICT Environments
ISSN 1795-6889
www.humantechnology.jyu.fi