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THE EFFECTIVENESS OF ICT IN SCHOOLS: CURRENT TRENDS AND FUTURE PROSPECTS

DISCUSSION PAPER

Teachers, teacher policies and ICT

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INTRODUCTION

Since the 1980s the integration of computer technologies in education has been a challenge for many educational systems throughout the world. The terminology to denote these technologies during the past decades changed quickly from micro-computer to NIT (new information technologies), IT (information technologies) and ICT (Information and Communication Technologies) denoting a shift from a technological focus to the more functional characteristics of these technologies. This shift in terminology resulted amongst others from changed expectations about the role of ICT in education. While in the 1980s and early 1990s ICT meant for most educational systems that students were learning about computers, since the mid 1990s the prevailing rhetoric in many policy documents was to conceive ICT as initiator of a societal change and as facilitator for educational reforms aimed at life long learning. These documents reflected a wish for making education fit into a knowledge society in which citizens would feel responsible for their own learning and would have the competencies to learn autonomously in challenging and authentic learning settings.

In educational reforms the teacher is the last but most crucial chain in the process of educational change. However when considering ICT related innovations in education we cannot conceive teachers as isolated actors. Teachers follow routines that they have learnt during pre-service training and on the job, they are required to implement curricular objectives and contents that quite often are formally established, they work within the constraints of the school organization having fixed lesson tables, etc. Innovations that require teachers to change many aspects of their daily routines are very demanding for them. Complex innovations can only be successful if a number of interacting conditions are met. As the integration of ICT is believed to be so crucial for the welfare and well-being of our future generations and because teachers play such an essential role, the following questions need to be addressed:

1. What is the impact of ICT on the work of teachers and their working conditions?
2. Are there ways that ICT can improve the effectiveness of the work of teachers?
3. What types of ICT-skills do teachers need?
4. Which policies and programs seem to be effective to prepare and motivate teachers for their role in education for the information society?

These are the kind of questions that already since the early introduction of computers in education are confronting policy-makers, researchers, teacher trainers and of course the teachers themselves. The reader should be aware that 20 years of research have not yet provided a recipe that has led to a large-scale integration of ICT in the lesson practices of teachers. Rather the result of experimentation, surveys and meta-analyses has been that our awareness of the complexity of these questions has been raised and that we are more realistic about the pace of change that can be expected. The purpose of this paper is to first review a number of concepts that need to be considered. Next we will discuss for illustrative purposes a few scenario’s of ICT-use in education (varying from relatively simple substitutions to more complex ones) and their potential implications for teachers. This is followed by a review of data from international studies regarding ICT in education (quantitative as well as qualitative). Next we will turn to address each of the questions posed above. Finally we will reflect on some of the dilemma’s that are likely to confront
educational actors in the forthcoming years as well as on the need to develop new and self-sustained models of teacher development that can be supported by (international comparative) research.

Conceptual issues

Researchers (from over 25 countries) who participated in the Second Information Technology in Education Study (SITES) started in 1997 to discuss the role of ICT in education and the implication of integrating ICT in the daily learning practices that take place at schools. Based on a review of the policy- and research literature, they concluded that at that time there seemed to be a substantial international consensus that ICT was not longer conceived as an educational goal in itself (for learning about ICT, as it appeared to be the case during the 1980s and early 1990s) but rather as a tool that can help facilitate a reform of education towards introducing pedagogical approaches by which students would be stimulated to play a very active role in the learning process. For teachers this reform would imply that they would have to redefine their role in the learning process by stimulating students to work on assignments in a self-sustained, responsible and autonomous way. In order to understand the adoption and implementation of this innovation, the SITES researchers identified four major domains of study, namely the curriculum, staff development, management/organization and ICT-infrastructure. A major hypothesis was that substantial changes in the intended curriculum would require accompanying changes in the other domains in order to raise the chance of successful implementation. On the other hand if, from bottom-up, changes would be initiated (that is in the implemented curriculum), such developments could only be sustained and transferred to the system at large if appropriate adjustments would be made in the intended curriculum and the other three domains.

As already mentioned earlier: the policy objectives of many governments and international organizations currently are phrased in terms of the need to introduce more student-centered approaches in education in which ICT is used to facilitate learning activities focused on authentic and complex tasks that require teamwork of a kind that students will also encounter in their future work place. This may be conceived as a change in the intended curriculum, irrespective whether it is formalized or not. A first important question is whether teachers accept this view, do they agree with it, do they experience a need for it? A next question would be whether and to which extent teachers are implementing these objectives and to what extent staff development facilities, school management support and ICT-infrastructure are sufficient for sustaining the innovative practices of teachers.

The extent to which teachers are inclined to accept the reform objectives will depend amongst others on their perception of the complexity, relevance and practicality of the intended reform. These issues will be dealt with in the next sections.

How complex are the intended changes?

In order to illustrate some of the complexities that potentially are or are not associated with integrating ICT and changing pedagogical approaches, let us imagine a case of a teacher who normally bases his lessons on a textbook, during half of each lesson he lectures (writing something on the blackboard or sometime presenting a transparency or pointing to a poster) and the rest of the lesson students are allowed to work individually in their work book, while the teacher is available for answering questions. Assignments are given for home work. All students in the class work through the book in the same pace. Once in a while there is a teacher-made test, consisting of mixture of open-ended and multiple choice items, which the teacher rates in order to monitor student progress. At the end of the year the learning of the textbook content should be completed and students should in a summative test demonstrate their knowledge of the content.
One may distinguish several scenario’s for applying ICT in such a situation. In a substitution scenario a teacher replaces some of the old technologies with ICT. For instance: the teacher may become enthusiastic about Powerpoint and use this for his lectures. Or he may allow his student to send their homework via e-mail to him. He even could present the tests electronically. Such ICT-scenario would not require much change and/or training. This is what may be called a cosmetic change: old wine in new bottles.

Another –more complex- scenario might be that the teacher gives up half of the time lecturing the content from the book. The student are required –on the basis of a few questions- to work in groups of 4 and produce the rest of the book, collect information and write it down in their own language, produce a report, and make a presentation in the end using a beamer and other presentation tools. Students use ICT whenever appropriate and feasible. Once the group products are ready the students should learn the content of each others work. They keep electronically track of their planning and progress. The teacher provides guidance and monitors progress, while the students also consult experts outside school as well as parents. The ratings of the presentations and group products is done by peers as well as outside experts and even parents, while the distribution of marks in the group is done by the group members. The products are published on the school’s Web site, while each student keeps portfolio-links to the parts to which he contributed.

This last scenario would be called transformational, because it radically changes the educational processes and probably also the outcomes. On the basis of inferences from case studies that were conducted recently (by IEA as well as OECD) the following might be a likely outcome: students would like the freedom they get, but also notice that it takes quite some time to do the project. Although they like to work in groups sometimes they report that it is not easy to agree on an appropriate approach. Some students dislike the fact that they did most of the work, others liked it because their mark was higher. Teachers appreciate the atmosphere when the students work in groups and feel that they learn to know their students better. Sometimes students even teach their teacher (about ICT). Discipline problems hardly occur anymore and it is remarkable that some lower ability students seem to gain a lot in self-esteem. On the other hand the teacher has the clear feeling that, although the students are very well acquainted with the content of their own group work, they do not master the content covered by the other groups, and hence that overall their subject mastery has decreased. The teachers do not think this is a serious problem, because they observe that student enjoy this way of learning of the subject much more than in the past. However, there exists some fear that, if the curriculum standards do not change, the student might experience problems when doing their final examinations in the school.

The first scenario in the anecdote above illustrates that the use of ICT does not necessarily imply a pervasive change for teachers. Many other examples could be mentioned that also would not affect the current education system substantially, such as: teaching about computers as an add-on to the existing curriculum, allowing students to play once in a while with applets (Java-plugins that allow for exploring particular phenomena in for instance math, science or biology), or requiring students to write their essays with a word processor.

The second example implies, when implemented at large in education systems, a quite drastic change. This is because it deviates substantially from the current teaching paradigm that according to surveys is prevailing in most educational systems: frontal teaching to whole classes in separate classrooms for fixed periods of time. Even more complex changes could be identified that have further implications for other components of the educational system (for instance the interior architecture of schools and the boundaries between school subjects). The changes as implied in this second example have many consequences for the roles of students and teachers, but also other educational actors as shown in Table 1.
Table 1: Expected changes from education in the industrial society to education in the information society

<table>
<thead>
<tr>
<th>Actor</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>Isolated from society</td>
<td>Integrated in society</td>
</tr>
<tr>
<td></td>
<td>Most information on school functioning confidential</td>
<td>Information openly available</td>
</tr>
<tr>
<td>Teacher</td>
<td>Initiator of instruction</td>
<td>Helps students find appropriate instructional path</td>
</tr>
<tr>
<td></td>
<td>Whole class teaching</td>
<td>Guides students’ independent learning</td>
</tr>
<tr>
<td></td>
<td>Evaluates student</td>
<td>Helps student to evaluate own progress</td>
</tr>
<tr>
<td></td>
<td>Places low emphasis on communication skills</td>
<td>Places high emphasis on communication skills</td>
</tr>
<tr>
<td>Student</td>
<td>Mostly passive</td>
<td>More active</td>
</tr>
<tr>
<td></td>
<td>Learns mostly at school</td>
<td>Learns at school and outside school</td>
</tr>
<tr>
<td></td>
<td>Hardly any teamwork</td>
<td>Much teamwork</td>
</tr>
<tr>
<td></td>
<td>Takes questions from books or teachers</td>
<td>Asks questions</td>
</tr>
<tr>
<td></td>
<td>Learns answers to questions</td>
<td>Finds answers to questions</td>
</tr>
<tr>
<td></td>
<td>Low interest in learning</td>
<td>High interest</td>
</tr>
<tr>
<td>Parent</td>
<td>Hardly actively involved in learning process</td>
<td>Very active in learning process</td>
</tr>
<tr>
<td></td>
<td>No steering of instruction</td>
<td>Co-steering</td>
</tr>
<tr>
<td></td>
<td>No life-long learning model</td>
<td>Parents provide model</td>
</tr>
</tbody>
</table>


The kind of changes as implied in scenario 2 conform to the directions of change that may be inferred from policy documents that appeared in the past decade. Given that these are the intentions of policy-makers (quite often also strongly advocated by industrial lobbies), one may question to what extent educational practitioners perceive these changes as relevant. This question will be dealt with in the next section.

Perceptions of educational practitioners

A main question regarding any instructionally related reform in education is: do educational practitioners want it? If not, the chance is very high, that the reform will fail.

Therefore a first main question is: do educational practitioners want a pedagogical approach that is more student-centered than traditionally has been the case? There are a few data sources that can throw some light on this question. A first source is SITES (see Appendix 1) and a second source is the Dutch ICT-monitor, which involves a yearly collection of a broad spectrum of indicator-data from all sectors of primary and secondary education, as well as teacher training institutes.
From the data that were collected in SITES as well as in the Dutch ICT-monitor there are clear indications that the policy orientation as reflected in Table 1 also have affected the expectations of educational practitioners regarding the future of schooling. A first observation comes from SITES. In this study school principals were asked to write down their most satisfying experience with ICT in terms of, amongst others, content, student activities, and what teachers and students gained from this activity. From the analysis of these data, it appeared that:

“Quite a number of school principals across countries reported on the contribution that ICT made to new curriculum approaches (such as cross-curricular), different roles for teachers, and productive learning activities for students.” (Voogt, 1999, page 215)

Another observation stems from the Dutch ICT-monitor, which included questions to school administrators and teachers about their expectations for the future with regard to characteristics of teaching and learning. Two indicators were constructed, that contained judgments of the current and future relevance of certain practices expressed in the following two sets of items:

**Teacher controlled teaching and learning:**
- Testing the whole class at the same time
- All students start with new content at the same time
- Students sit in fixed seating arrangements
- Whole class teaching
- All students work at the same pace and the same content
- The teacher is the most important source of information

**Student controlled teaching and learning:**
- Student frequently apply self-monitoring
- Students work at own pace
- Students work in groups or individually
- There are enough work places for group work
- There are different work places for group work
- Students at risk get separate instruction
- Instructional materials are available in the corners of the classrooms

From the results (see Figure 1 for illustration) it appeared that teachers (at secondary level) see teacher-controlled education as the main characteristic of the current educational settings, but they expect that

1. That is: approaches that are multidisciplinary and address content from several school subjects at the same time
student-controlled education will be much more important in the future. An analogous trend resulted from judgments that were made by school principals for the same two sets of items.

From the above one may tentatively conclude that there seems to be an awareness and even willingness among educational practitioners to accept that there is a need to adopt pedagogical approaches that promote student-controlled learning.

A next question is, to what extent student-controlled learning practices are already adopted in schools. The data from SITES may throw some first light on this question. School principals from lower secondary schools in 24 countries were asked about objectives, presence and ICT-facilitation of a number of pedagogical activities that are potentially indicative of student-controlled learning. For the purpose of our presentation here we will focus on the practice of independent learning by students.

**Figure 1. Indicators of teachers perceptions (in three consecutive years) of relevance of teacher-controlled and student-controlled education, now and in the future (from Pelgrum & ten Brummelhuis, 2001).**
Table 2: Percentages of school principals (in lower secondary schools) answering affirmatively to questions about policy, presence and ICT-facilitation with regard to independent learning

<table>
<thead>
<tr>
<th>Country</th>
<th>Policy to encourage</th>
<th>Present a lot</th>
<th>Realized a lot with ICT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium-French *</td>
<td>62</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>71</td>
<td>45</td>
<td>21</td>
</tr>
<tr>
<td>Canada *</td>
<td>70</td>
<td>46</td>
<td>28</td>
</tr>
<tr>
<td>China Hong Kong</td>
<td>85</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Chinese Taipei</td>
<td>80</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>Cyprus</td>
<td>67</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>65</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Denmark</td>
<td>68</td>
<td>44</td>
<td>16</td>
</tr>
<tr>
<td>Finland</td>
<td>92</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>France</td>
<td>78</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>Hungary</td>
<td>82</td>
<td>65</td>
<td>39</td>
</tr>
<tr>
<td>Iceland</td>
<td>82</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Israel *</td>
<td>92</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>Italy *</td>
<td>72</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td>67</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Lithuania</td>
<td>89</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>62</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>New Zealand *</td>
<td>75</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>Norway</td>
<td>87</td>
<td>64</td>
<td>16</td>
</tr>
<tr>
<td>Russian Federation *</td>
<td>33</td>
<td>31</td>
<td>13</td>
</tr>
<tr>
<td>Singapore</td>
<td>89</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Slovenia</td>
<td>90</td>
<td>46</td>
<td>15</td>
</tr>
<tr>
<td>South Africa *</td>
<td>66</td>
<td>38</td>
<td>16</td>
</tr>
<tr>
<td>Thailand</td>
<td>62</td>
<td>37</td>
<td>24</td>
</tr>
</tbody>
</table>

Source. Pelgrum (1999)

Note*: country not satisfying sampling guidelines

Table 2 contains the percentages of school principals (at the lower secondary level) per country who answered that it was their school's policy to encourage independent learning by students. Also the percentage of school principals is shown who indicated that this activity was already present a lot in their school. One may observe in this table that in many schools independent learning by students was claimed to be a policy goal of the schools. At the same time, in quite a number of countries this policy was perceived as being realized a lot by a substantial number of schools. The last column indicates to what
extent school principals attributed an important role to ICT for realizing the activity. Although these figures are a bit difficult to interpret (ICT can contribute a lot even in cases where the activity is realized to some extent, it is noteworthy that in some countries these percentages are quite substantial.

From the above we tentatively conclude that notion of student-controlled pedagogy is starting to get adopted in educational practice, and is starting to be implemented in a substantial number of countries.

Also the observations from the qualitative component of SITES (Module-2, see Appendix 1), in which cases were explicitly selected (by national panels) because they reflected an orientation on reform pedagogy, confirm the enthusiasm of teachers about the new learning arrangements, reflected by observations made in many cases:

**Improved student outcomes**
- Higher motivation, enjoyment in learning
- Improved self-esteem
- Improved ICT
- Collaborative skills
- Subject matter knowledge
- Information handling
- Meta-cognitive skills

**Improved teacher outcomes**
- Self-confidence/self-esteem through peer recognition
- ICT skills
- Pedagogical skills and/or other view on pedagogy
- Collaboration with colleagues

Less common but still interesting to mention were the following teacher outcomes:
- Less discipline and management problems
- The relationships between students and teachers improve
- Teachers learning a lot from students
- Teachers improve their presentation skills

Quite often it was (in the absence of objective evidence) believed that achievement of the subject was boosted.
Confronted with all these positive messages one may wonder which negative consequences were observed. Although enthusiasm prevailed negative signals concerned several aspects of the education process, as illustrated by the following quotes:

- **Learning:** “Students are used to get information easily using ICT and they don’t work so hard what is required for good learning”

- **Using ICT:** “Gradually, the students think it is normal to use a computer. Sometimes they do not like to use the Internet: ‘Again Internet?’ One teacher states that: “I have the impression that many perceive ICT more like a toy than like a tool.”

- **Planning:** “The students felt that the first part of the project, the planning phase, took too much time, and that they got bored. As one of the students says “I didn't like the planning phase. It was too much theory. It was much more fun when we started to work on the bathrooms and saw some results”.”

- **Teacher work load:** “It takes a lot of preparation time. Contributed to burn-out of teachers.”

- **Curriculum:** “The national curriculum is very restrictive”

An interesting observation from SITES is that despite the problems that teachers experienced (including a higher work load) their enthusiasm about the innovation apparently overshadowed these experiences.

Also it is worthwhile to mention that some teachers feared that achievement would suffer because of the inefficiency of the new approach (students loosing time with inefficient searchers, inadequate planning, etc.). Recent research seems to indicate that this fear is not purely hypothetical. Already from TIMSS-1995 onwards IEA is collecting a few indicators on ICT-use in science, mathematics and reading. The TIMSS-1995/1999 results (Beaton et al., 1996) seemed to indicate that students who use computers frequently for mathematics have substantially lower math-scores than their peers who do not use computers at all. Pelgrum & Plomp (2002) investigated this phenomenon further hypothesizing that a selection bias might be the cause, that is using computer for drill and practice activities by lower ability groups. However, on the basis of the analyses this hypothesis was rejected, as rather the didactical approach of teacher was found to be a potential explanatory factor:
The authors’ comments on the findings were:

“The strong association between student-centered didactics and the use of computers does fit nicely with the currently popular rhetoric regarding ICT, education, and the information society. This rhetoric has been formulated in many policy documents (European Commission, 1995; ERT, 1997; Panel on Educational Technology/PCACT/PET, 1997) which calls for the fostering of life-long learning together with the use of ICT as one of the cornerstones of the information society. In this rhetoric, a shift from a traditional pedagogical paradigm (teacher-centered, whole-class teaching, etc.) to a paradigm focusing on independent learning (doing projects, teamwork, etc.) is foreseen, and in numerous documents it is assumed that ICT can facilitate the adoption and implementation of such reform.

One may argue that a shift toward more learner-centered approaches in mathematics may result in having less time for the traditional focus on the reproduction of facts and “standard” problems and, hence, that scores on traditionally constructed mathematics tests may decline. Such an argument is no longer purely speculative or theoretical, since in Singapore it appeared that: “To facilitate the development of such a learner-centred environment (supported by the availability of technology and digital resources), a 10 to 30 percent reduction in curriculum content was instituted towards the end of 1998.” (Teng & Yeo, 1999)

The evidence presented in this chapter seems to suggest that the use of ICT tends to take place in situations in which a somewhat higher emphasis is placed on learner-centered approaches. A tentative hypothesis about the large score difference between the high-computer-use and low-computer-use groups is that this is caused by a pedagogical approach in which less emphasis is placed on competencies such as those measured in the TIMSS–95 mathematics tests. On the other hand, one may wonder why it seems that a high emphasis on student-centered approaches typically
seems to exist more in developing countries (Figure 2). Nevertheless, from a purely empirical point of view, one can maintain that cause and effect are indistinguishable on the basis of the data currently available.” Pelgrum & Plomp, 2002, pp. 317-330

Despite the fact that at the political level and also on the work floor of education there are positive expectations about the need for pedagogical change and the facilitating role that ICT can play, for the large majority of teachers the use of ICT in instructional processes is still a marginal activity. One may observe in Table 3 that the majority of students in most countries reported that they never used computers for mathematics.

Table 3. Percentage of students, in 1995 and 1999 and the differences (DIFF) between these years, indicating that they never used computers for mathematics

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>97</td>
<td>--</td>
<td>--</td>
<td>Greece</td>
<td>83</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Ireland</td>
<td>96</td>
<td>--</td>
<td>--</td>
<td>Canada</td>
<td>82</td>
<td>67</td>
<td>-15</td>
</tr>
<tr>
<td>Colombia</td>
<td>95</td>
<td>--</td>
<td>--</td>
<td>Switzerland</td>
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<td>--</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>94</td>
<td>95</td>
<td>1</td>
<td>Iceland</td>
<td>81</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Belgium (Fl)</td>
<td>94</td>
<td>93</td>
<td>-1</td>
<td>Netherlands</td>
<td>81</td>
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<td>-1</td>
</tr>
<tr>
<td>Russian Fed.</td>
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<td>97</td>
<td>3</td>
<td>New Zealand</td>
<td>79</td>
<td>73</td>
<td>-6</td>
</tr>
<tr>
<td>Belgium (Fr)</td>
<td>94</td>
<td>--</td>
<td>--</td>
<td>Romania</td>
<td>78</td>
<td>93</td>
<td>15</td>
</tr>
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<td>Korea</td>
<td>93</td>
<td>83</td>
<td>-10</td>
<td>Philippines</td>
<td>78</td>
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<td>Spain</td>
<td>93</td>
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<td>--</td>
<td>Kuwait</td>
<td>78</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Iran, Islamic Rep.</td>
<td>92</td>
<td>96</td>
<td>4</td>
<td>Australia</td>
<td>77</td>
<td>71</td>
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<td>--</td>
<td>Israel</td>
<td>76</td>
<td>67</td>
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</tr>
<tr>
<td>Latvia (LSS)</td>
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<td>95</td>
<td>4</td>
<td>Cyprus</td>
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<td>81</td>
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<td>South Africa</td>
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<td>United States</td>
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Between 1995 and 1999 only Singapore reported a considerable decrease of students who said that they never used computers for mathematics. For 1992 these percentages were for Austria, Germany (student samples from 9 out of 11 Bundeslander), Greece (only computer-using schools), Netherlands, Japan, United States: 44, 51, 74, 79, 65, 69, respectively. From these few comparisons with 1992, there is no indication that the use of computers in mathematics increased between 1992 and 1995. Rather, during that period, there seemed to be a trend towards a decrease in use.
As one might expect, there was rather a strong co-variation between student-to-computer ratios and the percentages of student who indicated that they never used computers in mathematics lessons. For instance, in the Russian Federation, Columbia, Spain and the Slovak Republic, the student-to-computer ratios were very high (which means a low availability of computers) and, at the same time, more than 90 percent of the students had never used computers in mathematics. On the other hand, in England where the ratio was very favourable, 45 percent of the students said that they never used computers for mathematics.

From the above one may tentatively conclude that there are clear indications that the educational reforms as implied in policy objectives that are adopted by a substantial number of countries, are accepted by educational practitioners. However, this has not yet led to implementation in the educational system at large. A promising observation is that teachers who have pioneered with ICT-supported student-controlled learning arrangements are quite enthusiastic, although in some cases also the fear exists that the traditionally valued knowledge of students may decrease.

Impact of ICT on the work of teachers

The integration of ICT may have a considerable impact on the work of teachers, in particular, if ICT is conceived as a tool that supports a change in pedagogical approach. Not only teachers need to change their roles and class organization, but in particular they need to invest energy in order for themselves but also for their students to get ready to introduce and manage new learning arrangements. For some teachers this means that they have to start with acquiring basic ICT skills. Moreover they need to determine which ICT-applications have added value for learning in their subject area. This implies that they need to locate and review regularly stand-alone applications (such as CD-Roms and subject-specific software), Web sources, etc. While doing this they need to be aware that this is not a one-shot operation because the information environment is continuously changing. Maybe most important and challenging for teachers who want to engage their students in open, flexible, authentic and autonomous learning environments will be to determine which basic subject, social and management skills students need to master in order to be able to function adequately in such environments. The change may also have implications for assessment tasks, because the new learning environments may mean a move away from summative methods of assessment (with paper and pencil and item-formats that can be relatively easily scored) to formative approaches in combination with open-ended products (such as reports and research papers that are created by groups of students).

There are indications that, indeed, these different aspects are experienced by teachers as time-consuming. During the early days of ICT-use in education teachers already commented: “It takes so much time. I would already have given up a long time ago, if my students would not have been so enthusiastic”. Also in SITES there were indications of increased workload:

- ‘Teachers found the workload far greater than they had expected; some expressed concern that long-term burnout might be an issue’
- ‘There was an added level of stress through the workload of learning new programmes. They gave up much personal time’.
- ‘The greatest workload involved planning activities incorporating the use of complementary resources and correcting students’ homework and research projects’.
- ‘We have our normal teaching workload to do and on top of this, we have to spend so much time and effort in this’.
From the above it appears that much of the workload may be related to a combination of factors. In a number of cases the innovation did not seem to be adequately facilitated. Also teachers may be inclined to develop most materials themselves, rather than to locate good practices on the Web and adapt these to their local circumstances. Maybe this is due to a lack of appropriate Web sources in their own language, but it may also be caused by a lack of knowledge about what the Web has to offer for them. In a number of cases the high workload may be caused by the teachers still wanting to control all activities of their students, which means answering many questions and running from one to the other student all the time.

One may wonder whether there are also positive indications that could balance the rather pessimistic view as sketched above. Such indications indeed exist, as illustrated by the following quotes:

- ‘It helps the workload even if you have different teachers helping to make up tests’.
- ‘Cooperation of teachers is influenced by their big workload, only some of them have discovered that computers do not mean extra work but that they can actually make their work easier’.
- ‘We all moan about the heavy workload, but we actually enjoy it’.
- ‘The innovation has increased teachers’ workload, but teachers who are involved find the innovation very interesting and rewarding’.
- ”The teacher is able to rest a little because the child is manager of his own learning with this machine. The teacher only has to see to it that the student is well occupied. The teacher can relax a bit, in other words, the machine allows the teacher to relax.”
- ”The atmosphere is much more relaxed when we work up here, then in other lessons. We laugh a lot and have more fun, but it does result in real work being done. We give up a lot of our spare time, which is something we wouldn’t do for the normal lessons.”
- ‘The relationship between teacher and pupils is more open and relaxed’
- “Students think that working in these Netlibris lessons is more independent than in other lessons. Everybody can work at one’s own pace. Students think that these lessons are relaxed and studying is fun because you don’t have to learn some specific area and there are no exams. “
- ”I am more relaxed, have more contacts with the students. Now, I am among the students.”
- “It gives less stress, but it is tiring”
- "While a working process is in progress, I can actually sit down and wait in the classroom to see if anyone wishes to discuss anything with me. We, in fact, work towards this. Our working process should then be done while the students are working. Then, I am also relaxed. I go to the classroom, look around and am pleased that they are working and I can sit back and relax. The other phases are a more strenuous process, e.g. the preparation of projects, to consider the standards in advance and procure the material. Done in several classes, this leads to the fact that one is under extreme pressure on individual occasions. Sometimes, I am compelled to work throughout the night. Then once again, there is a period of much relief.”
The positive message from these quotes is that despite the higher workload, teachers seem to enjoy working with the new learning arrangements. This could mean that, if solutions can be found for reducing the amount of planning and preparatory work, there is a high potential for the adoption of these approaches by larger groups of teachers.

A major challenge for policy-makers, school managers and teachers will be to find ways to reduce increases in teacher work loads that result from creating and initially introducing new learning environments. Part of this reduction may be gained through realizing contextual conditions that are prerequisite for student-centered pedagogical approaches. Among these conditions are:

1. Changes in architecture of school buildings
2. A new balance between traditional curriculum goals and new objectives
3. Cooperation between teachers
4. Creating sources for autonomous learning by teachers
5. Creating facilitating ICT tools for support and facilitating student-controlled learning arrangements

Condition 1 implies that the traditional school buildings with rooms that can accommodate roughly 30 students at a time are not appropriate work places for creating learning environments that allow for independent individual, team and project work. Once these change into more flexible open work places teachers are not longer forced into a role of being the sole director of the learning process but rather they are stimulated to cooperate in teams of colleagues that are coaching and supervising/advising at the moment that students are engaged in their self-directed activities. It is likely that such space arrangements, once students are used to it, will reduce the need for constant attention of each individual teacher.

One may even argue that such situations may create opportunities for teachers to free-up some time for their own learning.

Condition 2 is based on the reasoning that the introduction of new objectives has implications for the traditional curriculum. It could mean that some of the old goals and contents need to be dropped. This seems to have happened in Singapore where “To facilitate the development of such a learner-centred environment (supported by the availability of technology and digital resources), a 10 to 30 percent reduction in curriculum content was instituted towards the end of 1998.” (Teng & Yeo, 1999)

Condition 3 is related to work load. We learned from the case studies in SITES that creating innovative learning arrangements is a very time-consuming activity, which can be alleviated when teachers share the workload through teamwork and cooperation.

Condition 4 is based on observations that in student-controlled approaches to learning teachers will be confronted with many unexpected situations. Unforeseen problems may arise, for instance resulting from questions raised by students, not-working computers, dead-links on the Web, etc. In order to be able to coach and advise students, teachers need to be able to learn how to deal with these problems at the spot. Therefore, it is necessary to find ways that can support teachers and help them to develop confidence in dealing with these uncertainties. From SITES it appears that teamwork and cooperation with colleagues may help.

Condition 5 is important for implementing the intended changes in the education system at large. From the early innovators we have learned that currently the workloads are quite high especially because the new
Learning arrangements require more efforts in for instance communication, monitoring of processes, assessment of student products, and locating (but sometimes also) creating information sources on the Web. It is not difficult to imagine that ICT-tools can be created that can greatly facilitate these activities.

**Types of ICT skills needed by teachers**

School leaders still perceive the lack of ICT-related knowledge of teachers still as one of the main obstacles that obstruct the realization of their ICT-related goals (Pelgrum, 2001). In the literature and on the Web one may find many sources that describe the kind of skills teachers may need when integrating ICT in new student-controlled learning approaches. However, which competencies each teacher needs to acquire will very much depend on the specific circumstances that are realized in a particular school and also the kind of task profiles that are agreed upon when teachers start to work in teams. Some teachers may be particularly apt for lecturing to large or small groups of students, while other may feel especially confident in coaching or in technical matters.

One might argue that consistent with the reform objectives would be that teachers also need to become lifelong learners. This means that traditional teacher training models need to be replaced by models that allow teachers to learn independently from time and place, in a self-determined pace and supported by ICT (including teacher trainers who are virtually present in addition to physical presence). Important support tools would be for instance tools for self-assessment that direct teachers to knowledge sources that in their particular circumstances may be relevant for them. Moreover it appears that substantial learning can take place while doing the innovations, even by learning from students, as illustrated by the following quotes from SITES:

“…… *I learned from them. We realized that using the students to teach the teachers was a wonderful idea, because we wanted to build into the program this mentoring component, and when my mentee taught me, it kind of solidified our relationship. And the kids looked to us for guidance in what to do, in how they would use this wonderful skill that they had as a tool for learning. And we, the teachers, stepped away from the lectern and out of the front of the room and actually sat with the students and became facilitators.*”

Especially during pre-service training, teachers need to acquire a basic attitude of communicating success experiences with new learning arrangements to colleagues. This can be facilitated by offering ICT-tools for documenting and exchanging experiences. The currently available tools are still too primitive.

A further observation from surveys is that quite often the available teacher training courses are too much focused on technical skills. This problem also does not seem to have been solved adequately yet.

**Which policies are effective?**

At this moment it is difficult to answer this question, mainly because of a lack of international comparative data. Also one should be aware that the current reform plans in many countries are still from a quite recent date.

From the qualitative analyses that were conducted in SITES it seems that consistency between national and local policies is important for initiating and sustaining change. Moreover, school leadership is of crucial importance for realizing sustainable change, a finding that is consistent with the research literature on innovations and educational effectiveness. Quite often the educational practitioners, who participated in SITES indicated that they perceived the governmental policies as beneficial for initiating and sustaining
the innovations. On the other hand, existing policies, in particular when they concerned curriculum standards, were sometimes perceived as too restrictive and therefore in a substantial number of cases the innovations were organized as an extra-curricular activity. It is unlikely that such a solution will lead to sustainable and transferable development. Although it seems obvious that in future international comparative studies on ICT, the effectiveness of policies should be a major topic, experiences from the past have shown that this is also a quite complex issue, in particular when it has to be operationalized in an international study. Countries differ quite a lot in their policy structures, varying from centralized to decentralized systems. Locating policy documents and describing the policy ingredients in a comparative way and analyzing the relationships with indicators of effectiveness (that is the actual classroom processes, teacher characteristics, as well as student outcomes) proved to be almost impossible within the time-frames of international studies that took place in the past.

Summary and issues for discussion

This paper addressed a number of questions that relate to the issue of teachers, teacher policies and ICT. Summarized in short it was argued that ICT and educational reform are closely connected. Educational practitioners seem to accept the view that a new balance is needed between teacher-controlled and student-controlled educational settings. The experiences of the early innovators are rather positive. However, there are also indications that the workload of teachers is increasing as a result of the innovations. It is yet too early to determine whether this is a temporary phenomenon and to what extent ICT is actually compensating this increase or whether rigorous changes of the curriculum are needed.

For policy-makers a basic dilemma is how to balance between the need to maintain the relative stability of the traditional education system, while at the same time pushing towards distortions that are inspired by the reform rhetoric.

Below a number of issues will be identified that are meant as input for discussion at the joint Japan-OECD conference.

Radical change in education is difficult to realize as the stakes are high, such as expressed by a teacher participating in a discussion organized by the Dutch ministry of education about the design of the school of the future: “Do we want to risk a whole generation of students?” One may wonder if gradual change is possible. Isn’t this an operation comparable with changing traffic from driving left to driving right? Such reforms cannot be implemented gradually but they need to be effected suddenly. Is there any reason to belief that education is facing the same dilemma, that is do all essential components of the education systems (curriculum, teacher training, management/organization) need to be changes at once?

It is conceivable that in education a gradual development could take place on the basis of experiments with innovative scenario’s that first are applied on small scale. According to the experiences that were collected in SITES, the early innovators were, despite high workloads and other problems that they experienced, quite enthusiastic about the new ways of learning that they introduced. The main question is to what extent these innovations will prove to be sustainable in the local situations in which they were initiated. Answers will need to be found via research. A next question is to what extent sustainable innovations will also result in transfer to the education system at large. Statistical surveys can provide an answer to this question. However, one may argue that such surveys need to be very short-track sed in order to provide timely feedback to educational actors (from policy makers to teachers) on the pace and nature of change. It is conceivable that countries (individual as well as in cooperation with others) could create ‘virtual market places’ where best practices of successful innovations are stored and where schools and teachers can find examples of approaches that may be relevant for their own specific needs. Research could play a supporting role by critically evaluating and rating such practices. But also by observing such market place
(behavior of visitors, type of extractions, ratings of its offerings, workloads that result from applying these practices, etc.) valuable information could be collected on where products come from and where they go to and how the consumers value them. This could be input to policy-makers for determining which facilitating measures would be needed to further support the developments.

There have to be clear connections between national and local policies and classroom practices in terms of the elaboration at the different system levels of each of these components.

Educational policy-makers will probably need some courage in stepping back a bit. An important characteristic of the reform is that it is aimed at creating open and flexible learning arrangements. It is not longer an industrial process where the standards to which the final product should conform can be specified in advance. Rather it is likely that is should be conceived as a process in which one needs much flexibility at the micro-level in order to be able to quickly react to changing circumstances, individual needs, etc.

Probably as a result of this schools and teachers need to get more freedom in making choices that are appropriate for their circumstances. However, equal opportunities that most governments are striving for should not get worse and therefore regular monitoring is necessary to determine if schools in making their own choices do not deprive their students from opportunities that they might have had in other schools. In order to avoid that these monitors lead to teaching-to-the standard probably the design of the monitors should be radically different than currently is the case.

For the long-term sustainability of innovations it seems essential that, after initial attempts have proven to be successful, the need for reform is felt and advocated at the work floor of education As illustration we may refer to a school where recently (after re-building, curriculum re-design and staff training), despite the initial pessimistic expectations of some teachers a student-centered pedagogy was introduced for a few subjects. The outcomes of this ‘experiment’ seem so good that other teachers suddenly are convinced that this pedagogy might also considerably improve their teaching situation.

For education this would imply that well investigated sets of best practices would need to be made available.

Almost 20 years have past since the first micro-computers were introduced in education. The enthusiasm and expectations for educational added value were in the early days of introducing computers in education so high that even without governmental support, many schools acquired computers. Still ICT is not fully integrated in the educational process. Inspired by the current reform rhetoric dating back to the mid 1990s enthusiastic pioneers are again, often in the absence of adequate facilities, innovating their educational practices. However, without compensating measures the associated workload may be too high for sustainable development. Although ICT tools can greatly help to reduce workloads, teachers need to be trained to become aware of the availability and of how to use these tools. New ways will need to be found to maintain a cost-effective system of continuous staff development that is flexible enough to respond to quickly changing demands. Knowledge communities at the Internet could play a facilitating role. The school management will need to play an active role in stimulating and reinforcing teacher development.

It is unlikely that the reforms as referred to in this paper can be implemented via a top-down strategy. Governments can facilitate the intended changes via a variety of measures, amongst others creating data bases of well-documented best practices, financing site visits of teachers to the early innovators, relaxing the requirements of the traditional curriculum, investing in adaptations of school buildings, etc. However, granted that the momentum for educational change needs to be rooted at the level of schools and teachers (supported by students and parents), it seems of great importance that adequate instruments are made available for navigating, so that at the macro-level (national and international assessment), meso-level
(monitoring and self evaluation at school level) and micro-level (monitoring by teachers and self-evaluation by students) a continuous reflection on the actual position is possible. Of course, ICT would be indispensable for realizing this navigation tool in a way that vertical linkages can be established.
REFERENCES


ERT/European Round Table of Industrialists (1997) Investing in Knowledge: the integration of technology in European education. Brussels: ERT.


APPENDIX 1

Short description of data sources referred to in this paper

Second Information Technology in Education Study (SITES): Conducted under the auspices of IEA

Three modules

- Module-1 (quantitative + little qualitative): a snapshot picture (school-survey) of the situation regarding ICT in education. National representative samples of schools from primary, lower and upper secondary education (1998-1999);

- Module-2 (qualitative + little quantitative): observations of innovative practices in selected schools (1999-2002); Module-3: a repeat of Module-1 to determine changes across time and an assessment of readiness of teachers including performance assessment of ‘new’ competencies of students (funding fase).

Countries

- Africa: South Africa
- Asia & Pacific: Australia, China Hong Kong, Chinese Taipei, Japan, Korea, New Zealand*, Singapore, Thailand
- Europe-Central and East: Bulgaria*, Czech Republic, Hungary*, Latvia, Lithuania, Russian Federation, Slovenia*, Slovak Republic
- Europe-West: Belgium-French*, Cyprus*, Denmark, Finland, France, Germany, Iceland*, Italy, Luxembourg*, Netherlands, Norway, Portugal, Spain, United Kingdom
- Middle-East: Israel
- North America: Canada, USA
- South America: Chile

Note. *=only Module-1

Module-1: topics

- Curriculum: ICT-related objectives of the school, Presence of types of teaching and learning practices, ICT attainment targets, Realization of ICT-related objectives, Use of e-mail/WWW for instructional purposes, Percentage of students/teachers using WWW, Internet-related activities of students. Use of technology applications by students
- **Infrastructure**: Needs and priorities, Perceived obstacles, Expenditures, Software, Maintenance, Number and types of computers, Operating systems, Processor types, Hardware- Access to e-mail/WWW, Existence and content of Web home page, Number of computers not in use, Availability of peripherals, Availability of software types, Availability of software for school subjects, Hardware- and software-related obstacles

- **Staff Development**: Prescriptions regarding training of teacher in the school, Attendance by teachers, Expenditures on staff development, Types of internal information exchange, Availability of in-house/external training courses, Self-assessment of ICT skills

- **Management and organization**: Existence of written policies on ICT, Priorities for external support, ICT-related policy measures, Principal attitudes towards ICT, Use of ICT for administration/monitoring, Technical support infrastructure, Priorities for external support

- **Innovative practices**: Most satisfying ICT-related learning activities experienced

**Module-2**

- Case selection process (after national formation of expert-panels and nomination of cases)

- Case study process based on standard protocols, procedures and reporting formats

- Resulted in 174 cases: all coded on general characteristics