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Computers in the Classroom - A Disappearing Phenomenon?

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SUMMARY
The new notion of the "disappearing computer" challenges and relativises widely accepted assumptions about the role and benefit of computers in schools and classrooms. The "new technologies" may turn out to be used in less dominant and less explicit ways than this is currently envisioned. As a consequence, the pedagogical aspects of designing learning environments and of organising learning procedures should be given priority over techno-centric visions of future learning. Recent experience from two EU projects shows new ways of integrating interactive digital media with in-classroom learning scenarios.

KEYWORDS: *Classroom information management, media integration, computer integrated classrooms, disappearing computer*

INTRODUCTION: A NEW VISION OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Today, computers are present in the one or the other way in almost any school within the European Union and many other countries. Over the last couple of years, we have seen considerable progress in networking, both in terms of school Internet connections and in terms of intranet solutions. Also developing countries have implemented ambitious programmes to establish computers and Internet connections in their schools. A prominent example case is the Chilean nation-wide "Enlaces" programme (see http://www.redenlaces.cl). The introduction of new information and communication technologies (ICT) in schools has been accompanied by the quest for pedagogical innovation, i.e., new learning methods and curriculum revision. Whereas the proliferation of computers in the schools is a visible reality, the practical answers to the pedagogical challenges are much less consistent and clear. It is evident that pedagogical innovation cannot be directly "synchronised" with technical innovation. Over the last decades, we have seen qualitative changes in ICT at a very rapid pace. In not more than ten years, the paradigm of more or less isolated personal computers, which was introduced in the early 1980s as a successor of mainframes and timesharing systems, has been replaced by the networked computing paradigm. It is inconceivable that each paradigm shift in ICT could be reflected by a revision of our basic educational methods and goals. Now, there are signals from within the ICT community that future developments may no longer be centred around "the computer". I.e., educationalists may adhere to techno-centric paradigms that are already questioned by pioneers of the technology.

We should take these signals as an indication that the strategy of pedagogy following technology is inadequate. The conception and design of learning environments (in a broad sense, including physical space, heterogeneous resources, roles and responsibilities) is primarily a pedagogical problem, and pedagogy is based on long lasting and historically grown principles. The rapidly changing technology is a secondary, instrumental parameter. If we analyse and reflect the predicted and partly already observable new notion of the computer from an educational point of view, this will not be another adaptation of pedagogy to the development of ICT. Paradoxically, it is this new vision of ICT that relativises or downplays the role of the technology.

The new view of ICT is most sharply cristallised in the notion of the "Disappearing Computer" (cf. TIME digital, Feb. 28, 2000), which is also the theme of an ongoing European research initiative (http://www.disappearing-computer.net) at the crossroads of computer science, social sciences and innovative design. A similar vision has been propagated by D. Norman in his book the "The Invisible Computer" (Norman, 1998). The central claim associated with these notions is that interactive computing technology will no longer appear with a uniform product interface (standard screen, keyboard, a box and cables), somewhat screaming at the observer „Look, I am a computer!". New interfaces come with a variety of peripherals and different designs, and they will be embedded into spatial and physical „roomware" scenarios (cf. Streitz et al., 1999). Computing facilities may be amalgamated with the environment in the form of specific "smart objects" or "tangible bits" (Ishii and Ulmer, 1997). Weiser and Brown (1997) claim that such forms of ubiquitous computing will lead to a new age of "calm technology" which is characterised by having multiple computerised services around us in an implicit and unobtrusive way. This technology will no longer define the focus of our attention. Even the current notion of a "user" would be misleading if this vision were completely materialised. The point would no longer be the human-computer relationship but the availability of certain services located in the physical (and virtual) environment.

This notion of the "disappearing computer" creates a new perspective on ICT, but there are also some problems and potential misunderstandings:

- Already today, we "see" multiple processors being invisibly embedded in many technical devices such as automobiles, dish washers and other equipment in workplaces and homes. This should not be confounded with invisible computing in the above sense. In these other applications, computers essentially serve as controllers and regulators of processes within a device or between technical devices. The innovation that we are interested in has to do with information processing in which "the human is in the loop", i.e. with *interactive and cooperative* applications. Here, "explicit computing" is still predominant.

- Irrespective of its new shape and varied embedment, a computer remains a universal information processor in the abstract sense of a Turing machine. The ideas of universal computing, formal computer languages and the various computational abstractions that have been created to bring the programming of computers and the reasoning about computing to its current stage are not at all obsolete. They are also important for education as essential contributions to the human intellectual and scientific development. These fundamental ideas have to be reflected in our curricula for mathematics, informatics and philosophy, but this does *not* imply that the educational use of new digital media and ICT should be centred around the old explicit and uniform view of the computer. Whereas the universality of computing is a given, the relative uniformity of real computers will most likely disappear.

- The notion of the "disappearing computer" does, of course, not imply that computers would become obsolete, would no longer be used or would be replaced by alternative information processing devices. The latter may be another possible vision of the future, but it is not inherent in our understanding of the disappearing or invisible computer. Yet, there is more in this vision than the idea of computers getting out of sight (though potentially multiplied) in a concrete sense: Also on a conceptual level, social and technological innovation will most likely find new targets or "forefront technologies" beyond computers and also beyond the Internet. This, again, does not mean that these will be replaced. We see this in other areas such as, e.g., energy transformation technologies. There is still "local" innovation (today, for example; in the area fuel cells), but there are also old technologies with only small increments of innovation. There are no serious claims that energy transformation technologies will revolutionise our lives dramatically within a short period of time, as this is currently associated with computing and communication technologies. ICT as "calm technology" may imply that the changes are less dramatic than predicted. The new digital technologies can also be used to mimic classical technologies. This is the case with digital musical instruments, such as e-pianos, or with electronic paper. Of course there is a value added beyond the mimicry: you can use your e-piano directly conserve and replay your performance, you can convert into an editable representation using MIDI, you can feed it into a sequencing program etc. But basically, you can still rely on the old skills that you may have acquired with a non-digital medium.

In the sequel, I will try to explore some consequences of this new view of ICT under the "disappearing computer" heading for educational applications and particularly for our schools. A central question is in which ways computers may disappear in or from our classrooms ...

COMPUTER INTEGRATED CLASSROOMS

An early approach of how to adapt ubiquitous computing technology to the classroom has been described in Hoppe et al. (1993). It featured a combination of new hardware devices, namely big interactive screens ("LiveBoards") that had recently become available (cf. Elrod et al., 1992), with a networked classroom environment in which typical patterns of information exchange in a classroom were supported by specific groupware functions. One of the basic ideas was the provision "electronic worksheets" which could be distributed and collected by the teacher and which could be used in synchronous cooperative mode between students or be shared through the LiveBoard. This initial approach was demonstrated in 1993 by a fully functional prototype at the institute GMD-IPSI in Darmstadt. This was a proof of concept, yet the environment was installed in a laboratory and not in a real educational setting. The type of scenario was called a "computer integrated classroom" (CiC), reflecting the central idea of using computer and communication technologies to support interaction and information exchange in a face-to-face classroom.

The CiC idea was put into practice in the European long term research project "Networked Interactive Media In Schools" (NIMIS, 1998-2000, cf. Hoppe et al., 2000). As defined in the European ESE ("Experimental School Environments") call for projects, NIMIS aimed at supporting early learning, here particularly the first years of primary school. The NIMIS hardware includes a big interactive screen with a height-adjustable touch-sensitive glass surface particularly designed for the specific target group and interactive pen-based LCDs tablets integrated with the children's tables. The computers are connected in a local network and located in a separate room next to the classroom. The children's interface consists of the tablets and earphones or loudspeakers which can be used alternatively. Figure 1 gives an impression of this classroom installation with integrated hardware components and a big interactive board. The installation at a Duisburg public primary school is still in everyday use. Similar classrooms have been installed in a Portuguese school near Lisbon a rural school in England.

Figure 1: Scenes from the NIMIS classroom in Duisburg

The NIMIS software includes a special application for initial reading and writing ("Today's Talking Typewriter", see Tewissen et al., 2000) using pen-based input and speech synthesis, as well as a full desktop environment which facilitates archiving and communication functions for early learners even before they are skilled in reading and writing. The implementation and visualisation of login procedures, the flow of information, and ownership of data was one of the major challenges in designing a CiC for early learners. As a child orientated metaphor for handling and visualising data and different media, we introduced the metaphor of a "companion" as a virtual representative of the child. The child logs in to the computer by *calling the companion*. The companion appears and shows the child's documents (results of previous learning episodes, multimedia messages from classmates etc.) in the form of small preview images (see Figure 2b). Data organisation for young children is supported by means of automatic arrangement and distribution in folders marked with icons. Later, children may create their own folders and use drag and drop operations to arrange their documents. Different from standard operating system conventions, two children can log in at the same time on one machine and work together at their desktop. When the child logs out, the companion disappears and *goes to sleep*. The companion also disappears in its original place, when a child logs in on a different machine: The child is automatically logged out in the former desktop, i.e. at a certain point in time, a child's companion has only one defined location.

Figure 2a shows a typical action cycle and flow of information: Going to the scanner, the child calls his or her companion (a frog with a number in this case). The companion appears on the screen next to the scanner and shows the newly scanned image. Returning to the child's workplace he or she calls the companion again. The companion disappears on the scanner machine and appears at the workplace's interactive display, carrying the scanned image. The metaphor of letting a virtual companion carrying and managing the child’s data turned out to be a very natural way of promoting awareness of different concepts of data for the six year old children.

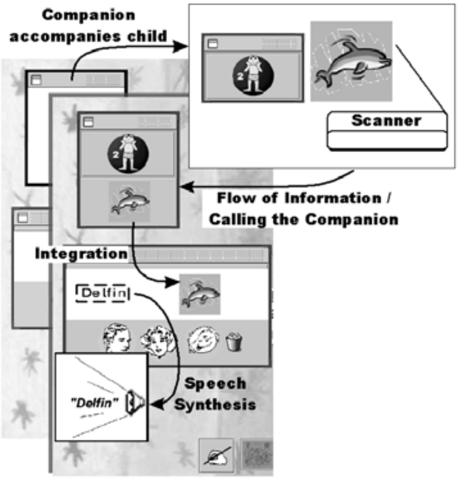

Figure 2a: Flow of information in a CIC

Figure 2b: A companion showing a child’s data

To make sure that new media technology supports learning and does not negatively interfere with well suited pedagogical procedures, we studied existing interactions and curricular activities in the three NIMIS primary schools. Although the new technology should not redefine pedagogy, new roles can evolve from these special environments for the teachers and the children. Teachers act as information managers, and thus have to learn about new ways of accessing information and to judge and handle qualitative new kinds of information. The same is true for the children: Without explicitly mentioning the computer as a topic, the children get used to managing their own data and to working with different devices and in different group constellations.

PRINCIPLES FOR INTRODUCING DIGITAL MEDIA TO THE CLASSROOM

Generalising from the NIMIS experience, we can formulate principles for introducing networked digital (rather than “computers”) in the classroom:

(a) Unification of media and learning activities on a digital platform

Educational media of the future will be unified on a digital platform. Negroponte's vision of 'Being Digital' (Negroponte, 1995) is particularly fruitful for educational scenarios since integrated digital media facilitate a free flow, re-use and recombination of the materials and products of learning in a classroom. New types of collaborative activities arise from these scenarios. However, the objects of learning are not only digital: Easy transitions between the physical and the digital world are facilitated and become a subject of learning processes.

(b) Supporting the classroom as a whole through an integrated networked infrastructure

Connecting learners in the NIMIS sense goes beyond providing internet access in a computerised classroom. Intranet facilities are seen as prior to internet access, not only for early learning. Integration, i.e. connectivity and inter-operability, fosters the communal aspect of the classroom and collaborative learning by giving flexible access to classroom resources for teachers and students and by facilitating a high degree group awareness.

(c) Design for reflection

In the NIMIS perspective, two types of reflection in learning environments are considered: (i) As an implicit result of the educational design of learning environments, learners have access to previous results and learning episodes as objects in the environment (e.g. through the visualisation of problem solving trajectories or through the provision of object repositories with versioning). This kind of reflection is an interactive process on the part of the human participants, such as learners, tutors or teachers. (ii) Additionally, certain types of analysis and interpretation on the part of the machine are also possible. The basis is a general architecture which includes history transcripts and plug-in facilities for intelligent monitoring and diagnosis (Mühlenbrock et al., 1997). However, we do not intend to build systems in which the learning process is under control of the machine as it was intended for „intelligent tutoring systems". Monitoring and analysis will provide local and partial feedback to learners or it can serve as decision aid for tutors or teachers.

(d) Priority of pedagogy over technology

Despite certain differences in educational tradition and culture between member states of the EU and even between single schools, European pedagogy for early learning is on average child centred and orientated towards active and constructive learning. Learning activities in primary school classrooms are typically distributed, the teacher being a manager of these multi-threaded activities. Certain technological scenarios might lead to more centralised control or to higher shares of individualised learning as opposed to partner work. Such potential changes originating from the inherent logic of the technology without a clear pedagogical justification should not be accepted. The design of educational scenarios should in first place be based on pedagogical premises and objectives.

(e) Consequences for teachers' roles and competence

We believe that tomorrow's teachers will have to fulfil the role of classroom information managers. Already, today particularly primary school teachers act as managers of rich distributed classroom activities and of a variety of resources. With the help of advanced technologies, certain routine tasks such as the detection and correction of individual errors may be partially left to a computerised support system. This will enable teachers to concentrate even more on aspects of knowledge management and on supporting special needs. Given the ease of use of the new technology, there is no need for spending more efforts than today on system-specific ICT training for teachers. However, classroom information management will become a new prominent issue in teacher training and in teachers' professionalism. It will involve aspects of knowledge processing and representation, the design of learning materials and group scenarios for collaborative learning and new technology supported methods for reflection and analysis of classroom experience.

PATTERNS OF DISAPPEARANCE

The concrete arguments and suggestions put forward so far can be seen as a plead for new and more intensive forms computer use in classroom. So, is the "disappearing computer" argument not more than a provocative rhetoric? Certainly, it is intended to be also rhetorical in that it questions an existing hidden agenda of ICT in education (e.g., the hope that bringing computers and Internet to schools will somewhat magically improve the quality of learning). Yet, certain concrete aspects of disappearance that have been attributed to new forms of computing technology in general are also reflected in specific ways in pedagogical scenarios:

(a) "Computers in disguise" (mimicry)

In the NIMIS classroom, the pupils' workplaces do not have too much in common with a standard PC. It was interesting to see that initially, parents in first place, but also the children expected the NIMIS classroom to be a "computer room", but when we asked the children after a while if they were really working on a computer we found considerable doubt and few direct affirmative answers. Indeed, the NIMIS workplaces with the tablets mimic the traditional school desks with slates. Pen based interaction was not known to the kids as a form of operating a computer before. In this sense, the NIMIS classroom successfully demonstrates a form of mimicry. As for other forms of computer mimicry, the example of digital musical instruments had already been mentioned. These are obviously also pedagogically relevant. Chess computers are one of the few commercial examples of computerised interactive devices with interface mimicry in the form of physical objects, namely the chess pieces. Similar forms of interface mimicry have also been tried out in educational contexts (cf., e.g., Kusunoki et al., 1999; Eden, 2002).

It is unclear if the educational use of pen based pocket computers or PDAs (cf. Roschelle & Pea, 2002) should be classified as a form of mimicry. PDAs come with the claim to be universal computing devices, although they have a non-standard appearance. The answer (to the mimicry criterion) would be more likely 'yes' for mobile phones with multimedia interfaces, but the educational relevance of these is still hard to define.

(b) Hidden computers and conceptual disappearance

In the NIMIS classroom, the pupils do not see and do not directly interact with "the computer". This makes a conceptual difference since it is plausible to assume that non standard interfaces do not evoke fixed ideas about using a computer (which are nowadays even present in very young learners). From a technical point of view, we can conceive the "hidden computer architecture" as a network of servers and services connected to very differently embedded and shaped interfaces, including task-specific interactive objects and pen based interfaces.

Pen based interfaces such as tablets, e-book readers or big interactive displays mimic paper and pencil or chalk and chalkboard, they support the "paper metaphor" also without being electronic paper in the narrower sense of the word (cf. Ditlea, 2001). We found that particularly older students and adults show a certain resistance to using "fuzzy and imprecise" free hand input for annotations and sketches if they are aware that there is computer behind. Conversely, if we could achieve a good acceptance of free hand interfaces for certain tasks (e.g., design and creative planning), this would indicate that the users' conceptual understanding or their mental models of the situation were no longer focused on the computer. In this case, the computer would not have disappeared physically, yet, in a sense, mentally. We can assume this is true for any kind of successful interface mimicry.

(c) Computers not in classrooms

Very interesting debates are centred around the question where to place computers in schools. Should computers in higher numbers (one computer for one or two students) be concentrated in "computer rooms"? If put into classrooms, how many computers make sense, how should they be arranged and located? Here, our experience confirms that the general form of classroom organisation makes a big difference for the use of computers in classrooms: In primary schools with distributed and multi-threaded activities, it is no problem to put one or two computers in a corner and to use them as one potential learning station in the classroom "learning parcours". In secondary schools which, at least in Germany, rely on a more homogeneous teacher centred and all-students-in-a-line learning style, it is much more difficult to make use of a small number of computers. In this case, alternative locations (if not the "computer rooms") could be the school library (if there is still one, it should certainly have computers and Internet connection) or rooms for "digital group work" in phases of distributed project orientated learning. This, of course, requires changes in the prevailing teaching and learning styles and in the organisation of the learning process.

RECENT EXPERIENCE AND PERSPECTIVES

Within the European SEED project (IST-2000-25214), the Collide research group in Duisburg is currently testing new forms of using digital media in the classroom with a group of associated teachers. This endeavour is based on the premises that we accept the given curriculum and do not introduce new computer orientated content (1), that we do want to maintain, maybe enrich, each teacher's grown teaching style and preferences (2), but that, together with each of the teachers, we want to achieve a *richer and more integrated form of using interactive digital media in the classroom* (3). As for (3), our central focus is on the expressive and productive function of media as opposed to their container function in "content delivery". The theoretical background of this approach is elaborated in some detail in an article by Hoppe, Kynigos and Magli (in this volume). In these learning scenarios, we are using tools that support both free hand input which is not interpreted by the computer together with "visual modelling languages", e.g., to model system dynamics or for stochastic experiments. The modelling tools are described in another paper (Hoppe, Pinkwart, Lingnau, Hofmann and Kuhn, in this volume).

Figure 3 illustrates the use of modelling tools and pen based input devices in a probability course in 9^{th} grade. The modelling environment (*"Cool Modes"*) allows for interactively setting up stochastic experiments using a specific visual language. The modelling environment supports workspace sharing between computers and the creation of shared objects to accumulate data from different working groups.

Figure 3: Modelling tools for stochastics

Figure 4 is taken from a biology course in 12th grade on system dynamics (exponential and logistic population growth, consumption of natural resources, interacting populations such predator-prey models). In the concrete situation, the teacher works with a big interactive display using the *NoteIt* free hand annotation tool. A scanned-in image of the development of coffee production in Brazil has been loaded into a *NoteIt* page. The data show a periodic pattern but also an increase over time. The teacher wanted to construct a linear approximation of this overall increase. Since *NoteIt* does not provide parameterised geometrical shapes but only free hand input, he took a ruler designed for the chalk board to draw a straight line on the electronic board. The result was perfectly OK, but the teacher articulated afterwards that he felt uneasy using the physical device as an add-on to the digital representation. He thought the computer tool should provide a line drawing operation and found that his "fuzzy" way of achieving the goal was inferior to a "clean" computer operation.

This example is very much in line with the general observation stated in the "patterns of disappearance" section above. Yet, what is really bad about this blend of the digital and the physical-analogue? The result is on a digital level and thus maintains the full potential of being electronically archived, re-used, distributed, multiplied and post-processed. As for the input process, a line-drawing operation would not necessarily have been better than this "brute force" method: The analogue device is clearly visible to the audience, and, as for the adjustment of the straight line, it offers more degrees of freedom than a computerised line drawing operation which usually requires fixing one point first or just allows for parallel movement of a given line. Even though the teacher was not satisfied with his solution, the idea to take the ruler was ingenious! In all our previous experience, we had not seen this specific combination of digital and physical tools.

In an unbiased view, this example shows that the “digital mimicry” works and is spontaneously accepted, though questioned intellectually.

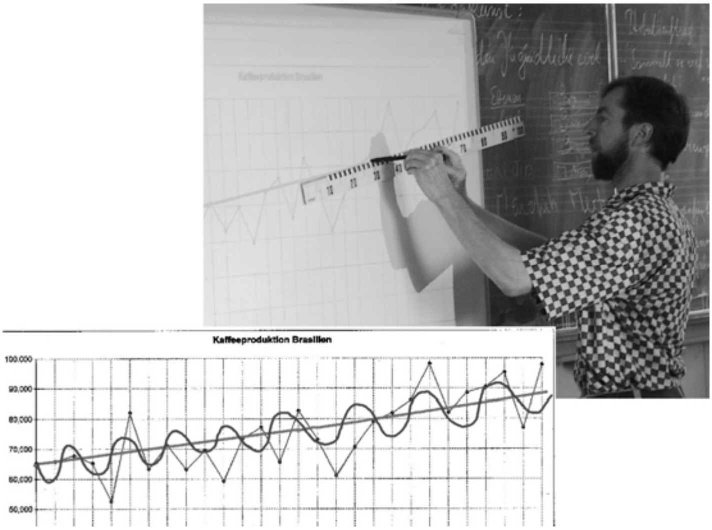

Figure 4: Ad hoc use of an analogue device over an interactive digital representation

The NIMIS and SEED experiences demonstrate that a new understanding of interactive digital media beyond explicit computing can indeed lead to innovative ways of using ICT in various learning settings. New dimensions are opened beyond individual usage by supporting group interactions, beyond information delivery (so typical for web based scenarios) in terms of expressive and creative use of the media and beyond the traditional expectations regarding computers by crossing the physical-digital barrier.

ACKNOWLEDGMENTS

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Σχόλιο [FT1]: Seite: 1
TODO: Unwichtigen Kram weiter gnadenlos kürzen!!! SnapGrafix-Abbildung neu anlegen. Intelligent Support (<= klaren Bezug zu T3 herstellen) und Collaboration (<= kürzen!) besser integrieren und zusammen mit den Perspectives (insgesamt) kürzen. Damit einhergehend die Experiences knackiger und konkreter gestalten. Einführung der Methode präzisieren. Der Punkte zu ”technical quality” sind nicht nachvollziehbar sehr unterschiedlich, trotzdem: Mehr Kontext (etwa didactic claims?? erwähnen), Schülermeinungen und T3-Änderungen kommentieren.