Supporting Collaborative Activities in Computer Integrated Classrooms – the NIMIS Approach

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Abstract

This paper presents the concept of a collaborative computer integrated classroom (CiC) specially designed to achieve a unique combination of interactive and collaborative software with spatial arrangements, special furniture, and new peripherals including furniture ("roomware"). Although, technologically innovative, the CiC approach respects grown pedagogical traditions and classroom procedures. In-line with the notion of ubiquitous computing it tries to augment the real classroom instead of defining a virtual learning environment.

Based on these principles, the European NIMIS project has put into practice a specific classroom environment for early learning with general tools and specific applications supporting literacy-related activities. In addition to the collaborative nature of the classroom scenario as such specific mechanisms for co-construction in shared workspaces are provided.

1. A collaborative computer integrated classroom for early learning

1.1. Ubiquitous computing in the collaborative classroom

The notion of "ubiquitous computing" has been developed in the 1980s at Xerox Parc [1]. If re-conceptualised today, it could be characterised as using special purpose networked digital devices (rather than uniform computing equipment) embedded in natural environments, be it at home, at work, or in educational settings. The NIMIS project aims at developing a special version of ubiquitous computing for a "computer integrated" primary school classroom. This is in-line with recent integrative approaches to designing new interfaces and interactive devices, e.g. under the notions of "The Invisible Computer" [2], "Tangible Bits" [3] or "Roomware" [4]. A first version of the CiC as a general concept and first prototypical implementation are described in [5].

This concept lets the traditional computers go more to the background and invents new specialised devices and interfaces driven by appropriate software architectures. Integrated approaches take aspects of software, hardware and furniture into account when designing media environments. To be successful in terms of usability for and acceptance by the envisaged users, the construction of such environments has to take the existing social interactions and needs into account. Our recent experience and most elaborated application of an integrated room is a CiC for young children (5-8 years old).

Evolving from the specific application for early learning, there is a clear general need of explicitly defining the share of responsibilities and roles in the interaction of humans and machines in CiCs. In this concrete design for early learners we follow these principles:

- provide uniform access to multiple representations of media and use a variety of information sources;
- do not let the technology "get in the way";
- facilitate existing classroom procedures, and;
- use a modular software architecture which allows e.g. plugging in intelligent modules.

In the CiC we use the following basic hardware components:

- a big interactive screen specially designed with a height-adjustable touch-sensitive glass surface,
- interactive pen-based LC-displays integrated with the children's tables as the primary input device of the children.

The computers as such are "invisible" (i.e. concentrated in a separate room and not operated directly during a lesson) and integrated in a LAN. Fig. 1 gives an impression of an embedded classroom installation with integrated hardware components, particularly flat interactive tablet displays, and a big interactive screen.

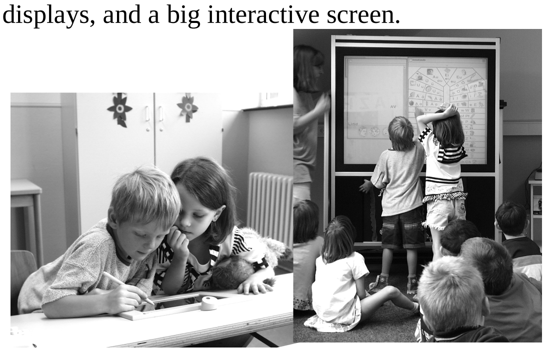

Fig. 1. Use of pen-based devices

To make sure that new media technology supports learning and does not redefine well suited pedagogical procedures, we studied existing interactions and curricular activities in the classrooms of today's primary schools. The CiC instances that exist now in schools in Germany, England and Portugal, have been setup in close cooperation with teachers and test groups of young children.

Although new technology should not redefine pedagogy, new roles may 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 select from 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 manage data and information and work with different devices and in different group constellations supported by the technology.

1.2. Classroom and school environments

Kirchstrasse and *O Nosso Sonho* are two of the three schools collaborating in the *NIMIS* project, that have installed the CiC in one of their classrooms.

GGS Kirchstraße in Duisburg is a normal curricular primary school. In general, the children are taught in individual work phases in which the teacher organises the learning environment but the structuring of activities, (what has to be done when), is done by the children themselves. The teachers act, most of the time, as moderators and they decide what the line of work will be for the school day. Currently, the school is changing the way that reading and writing is taught. The traditional way of letter-by-letter or whole-word learning is now being replaced by the method called "Reading through Writing" which is provided by the T^3 application (see Fig. 5).

The NIMIS classroom in Duisburg is equipped with 8 computers, which are situated in a separate room. There are six tables in three groups, with built in WACOM tablets, loudspeakers and an optional keyboard and a large interactive screen for finger based input (see Fig. 2).

Fig. 2. The NIMIS classroom in Duisburg

O Nosso Sonho is a school located in the suburbs of Lisbon, which covers a wide variety of learning stages and activities: kindergarten, free time occupation, psychological support, and professional training. Further, *O Nosso Sonho* is not a curricular school, and its pedagogical approach aims at providing the children with the possibility to choose, freely, the daily activities and this way promoting the acquisition of mature decisions by the children. The pedagogical strategy begins in the spatial organisation of the school. So, the learning activities are distributed in different rooms with different goals and aptitudes. For example: (1) in the *Dramatic Room*, children can do dramatic performances of fairy tales or free theme stories, and (2) in the *Intellectual Room* is a place for the children to write, play with the computers (games, puzzles, educational software, etc.) and with traditional educational games.

The CiC is installed in one corner of the Intellectual Room (see Fig. 3) and this new setting allows the children to continue doing their usual activities as well as having the opportunity to bring the dramatic performances to the computerised environment and together to act out their own stories.

Fig. 3. The NIMIS classroom in Lisbon

2. General tools for classroom management

2.1. The NIMIS desktop

To provide networked interactive working and collaboration, the NIMIS Desktop has been developed as a multifunctional tool to be used by pupils and teachers cooperatively. The basic functionality is shown in Fig. 4.

2.1.1. Companions and archiving

As a child-oriented metaphor for handling and visualising different objects and media and for providing consistent orientation and guidance, we have introduced a *companion* or *computer friend* as a virtual representative of the child. The child logs in to the computer by *calling the companion* from a window on the desktop. The companion appears and shows the child's data with small preview images (see Fig. 4, in the upper left). The children's data view consists of a list of symbolic general purpose and special (e.g. incoming mail) folders. Older children may start thinking about their own organisation and use special folders and drag and drop operations to arrange their data.

2.1.2. Login procedures and information flow

To cope with the special requirements, NIMIS has designed and implemented new policies for desktop operations, which differ from the usual conventions. To support the physical cooperation of children sharing one tablet on a table, the NIMIS desktop allows for two children to log in at the same time on one machine and work together at their desktop. Both have their own companion to which they can hand over documents they have produced. Joint products can be copied using a desktop "copier" and may be archived individually. When a child logs out, the companion disappears and *goes to sleep*. This is also true, 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 one defined location.

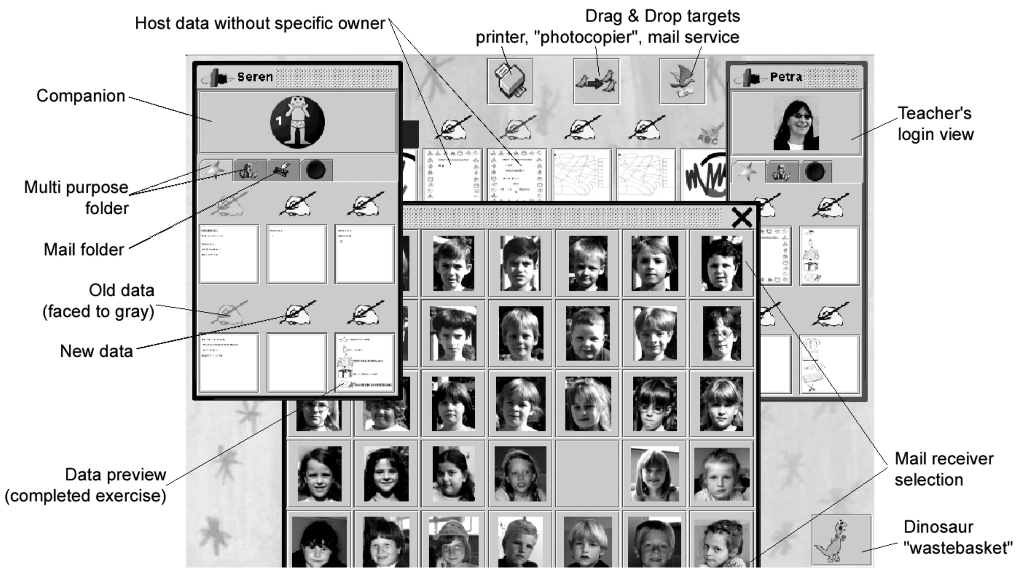

Fig. 4. Elements of the NIMIS Desktop

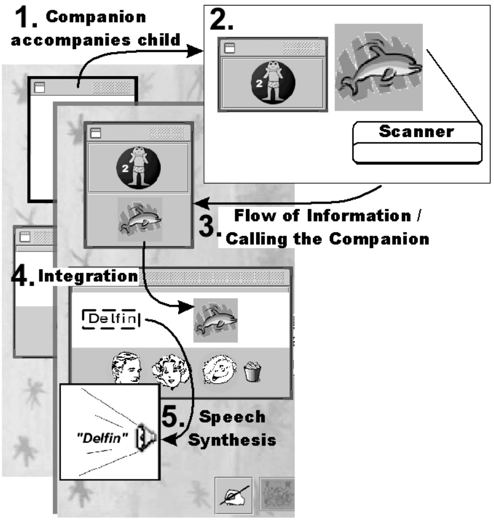

Fig. 5. Typical flow of information

Fig. 5 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.

3. Forms of collaboration in the NIMIS classrooms

3.1. General features

The general design of a NIMIS classroom is focused on supporting the ordinary classroom activities, which are typically multi-threaded in that pupils work alone, in pairs or in larger groups on potentially different topics or assignments. A main function of the teacher is to stimulate, coordinate, and, if necessary, control these multiple individual and collaborative activities. In this sense, the teacher can be seen as a manager of classroom activities and of information resources. To support this, the NIMS classroom provides a supervision interface, which displays the location of logged-in children in the classroom. The interface also allows for sending assignments to the children and to observe their current state of work.

In addition to supporting general classroom information management, NIMIS develops specific applications in the area of early literacy, including the acquisition of initial reading and writing skills as well as aspects of story creation (writing, enacting/playing and watching). Two example applications are described in the following section.

All NIMIS tools and applications can be run in shared workspace or synchronous communication mode, supported by the Java MatchMaker communication mechanism (see section 4). This allows for co-constructive activities in different areas of literacy and narrative expression. However, again, NIMIS is not focused on remote communication and children may also just cooperate sitting side by side on the same table. This kind of collaboration is supported by the specific login and archiving mechanisms described above. Generally speaking, the NIMIS conceives collaboration as a ubiquitous activity in the classroom, which is only partially mapped onto technically mediated communication.

3.2. The case of T^3

The T^3 ("Today's Talking Typewriter") application which is primarily used in the German classroom supports the method of *"Lesen durch Schreiben"* (Reading through Writing, RtW), a well known method for teaching reading and writing skills to early learners.

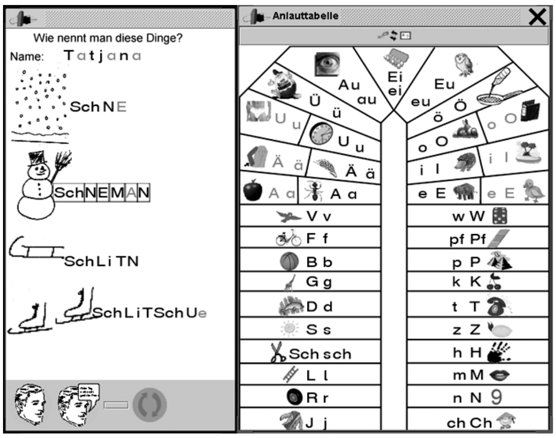

Fig. 6. The T^3 application

The method is based on the principle that children first start to write phonemes which they derive from decoding spoken words. In T^3, this is done using a "phoneme table", from which they drag letters into a workspace to form phonetically (not orthographically) correct words. Immediate feedback is given by a Text-to-Speech system (TTS) so that the children can listen to the word they have composed (see Fig. 6).

In the non-computerized classroom practice, the feedback cycle starts with an exact pronunciation of the writing provided by the teacher. Using T^3, children can press the "speak" button whenever they wish to hear the complete text or a single word that they were most recently working on.

The T^3 application is currently being enhanced with intelligent support. The support is based on a general architecture for implementing both personalized as well as functionally embedded agents [6]. Intelligent support is not refined to individual feedback but includes support for collaboration following a "peer helper" principle [7]. Take, e.g., a situation in which one child is working on a word, which has been written by other children before. The work of the child will be supervised by an implicit agent, which means an intelligent module basing on the common agent architecture but without a visible "body". If the agent detects that there were other children who had problems related to a similar word, a selection of these children will appear (see Fig. 7) and the child has the choice to hear the words of the other children, working with the word written by an other child or initiating collaboration for working together on this word.

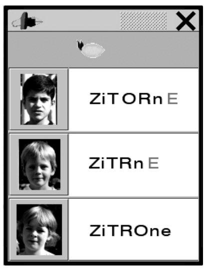

Fig. 7. Visualisation of individual results.

Collaboration here could take place both outside and inside the system. Outside could mean that one will ask the other child directly and they will work together at the same workplace. Inside the system a collaborative session can be initiated where two or more T^3 applications coupled. The children share the workspace so that everyone will see all changes made by the other without loosing local data. In the current implementation the phoneme table will be divided so that one child gets the vowels, the other children will have the consonants. While working together on a word one child can act now as a "vowels advocate" and supervise the using of vowels in a word while the other child has the control of the consonants needed for a word (see Fig. 8).

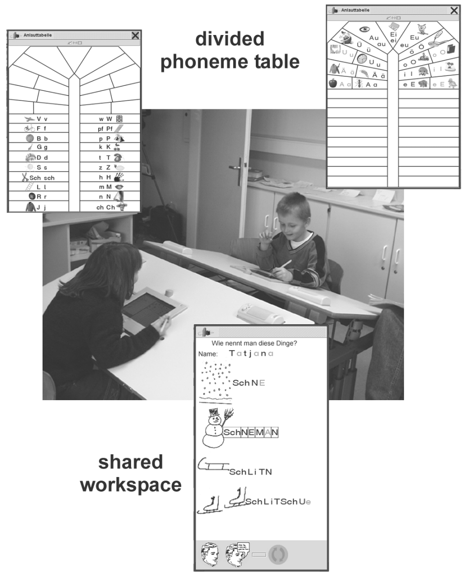

Fig. 8. Collaboration with T^3.

3.3. The case of *Teatrix*

Teatrix is a collaborative virtual environment for story creation, which aims at providing effective support for young children (7-9 years old) developing: (1) their notions of narrative, through the dramatisation of different situations; (2) their social relations, through the interaction by means of their characters; and (3) their ability to take different perspectives across the experience of wide range of situations.

3.3.1. Collaborative story creation

Narrative and storytelling start to make part of our lives since early childhood, when children start to hear the first stories through their parents and siblings' voices. After having explored the world that surrounds them, children start to acquire their first concepts about the objects and events of the world, begin to construct more decentralized plays and start also to include the others in their make-believe world. At this point they also start to use common objects in such a way that they became magical and powerful props in their stories, for example: a stick that becomes a horse [13].

Following Piaget's theory, this evolution of the make-believe activities allows children to perform different roles, gain control of the course of the action and acquire the skills to organise the sequence of a play and most importantly to project these experiences into the cognitive and social requirements of the real world.

Based on these evidences we decided to bring the make-believe activities to the computerised environment and to provide the means for children to collaborate in the story creation process and implicitly promoting social interactions among them.

3.3.2. Design of Teatrix

Before designing *Teatrix*, a set of informal experiences was run in the Portuguese school *"O Nosso Sonho"*. In these informal experiences, we observed children of several ages performing fairy tales in different settings: theatre and puppet scenes. The results of such observations showed that:

- during the story performance, younger children (4-6 years old) needed more scaffolding from the teacher than the oldest ones (7-8 years old);
- children spent a long period of time to characterise (in order to better "incarnate" their characters);
- the older the children the better they followed their roles in the play, and stayed in character throughout the story progression;
- at acting time, older children coordinate between themselves in order to ensure that the story was being conveyed to the audience in the meaningful way;
- the teacher usually played the role of the narrator, and acted also as a mediator;

Based on these results we designed *Teatrix* [12] in which follows a theatrical metaphor and has as target public children between 7 to 8 years (similar decisions and results concerning the children ages were found in the Kidstory i^{3}net project [9]).

The story creation environment is divided in three steps, strongly related with the theatrical performances:

1. *The Backstage* – this option offers the children the possibility to prepare the scenes, props and characters for each story.
2. *On Stage* – which provides the children with the possibility to initiate one story and to start the acting. Before starting the acting activity, each child has to choose a character to control. In this environment, there is also the possibility to have system-controlled characters After having chosen the characters, children are ready to start their performances, which take place in a collaborative 3D world (see Fig. 9). From the story creation process a "*film*"-like object is created. This "*film*"-like object offers the children a product they can analyse and even reconstruct in future performances.
3. *The Audience or Public* - is based on the artefact produced from the story creation process. In this phase, children can be the *audience* of their own performances and watch their previous performances and also have the possibility to write about those stories.

3.3.3. Collaborative story creation in Teatrix

Teatrix can be considered as a system that enables collaboration since it provides the children with the necessary means to act autonomously, but at the same time being aware of the presence of others and having freedom to coordinate efforts in order to achieve a collaborative story.

On Stage option is a collaborative tool that allows several children to work simultaneously on the same story. In this case virtual reality technology plays an important role in this phase, because it provides the children with the means to explore the scenes during the story creation [8].

Fig. 9. Teatrix: On Stage Option - two children playing with two different characters

The story evolves whilst the children work together to achieve a common goal: their story. Furthermore, the children get much more from an interaction or experience if in the end they will create a meaningful artefact, that they can exhibit as a proof of their personal or collaborative work [10]. Each child acts in the story by means of a character, her/his adopted character.

Each character in *Teatrix* has a role to play, for example: a villain, a hero, a magician, etc. The roles definition was based on the seminal work done by Propp [15] on one hundred Russian folktales (see [14] for more details on the characters definition), which define and establish the functional role of an agent, by means of the specification of the actions and roles for it.

During the story creation process, each child sees the actions performed not only by her/his character but also by the characters in the same scene. The children can talk to each other in order to coordinate their activities as well as collaborating through their controlled characters. For example: the magician (controlled by one child) may need to give a magic element to the hero (controlled by another child) for him to defeat the villain.

4. Implementation and technical platform

The NIMIS desktop, the T^3 and *Teatrix* applications were developed using the Java programming language. The communication and collaboration is technically based on a Windows NT network and the *Java MatchMaker (JMM)* software library and server [8]. Every Desktop is connected via *JMM* to a central *ClassroomService*, which supports centralised access to

- a database where the core information about the users is stored (e.g. to which group using the classroom a child belongs, which is the child's companion, etc.),
- central logging of children's activities within the classroom (e.g. starting an application, writing a word with the T^3 application) and
- monitoring central control facilities for the teacher (e.g. to show who is logged in where and what applications are currently used).

T^3 and *Teatrix* use a general Java-based XML format for storage. The audible feedback is provided by an external Text To Speech (TTS) system.

The T^3 application relies on a Prolog conversion algorithm to provide special phoneme control sequences that are used to emphasise certain parts of a word or to prevent the TTS system from spelling every single letter in a word.

Teatrix application, in addition to the standard *Java Development Kit*, also uses the Java 3D API for the implementation of the 3D environment (world, characters and props) and the *Java Expert System Shell* (Jess) for development of the agent's reasoning modules.

5. First experiences

For the teachers and children in Duisburg the use of the NIMIS classroom was a seamless transition from the normal classroom to the computerised environment. After a short period of initial guidance most of the pupils were able to use the NIMIS environment autonomously, i.e. particularly teacher-independent writing. This enables the teachers to use their time more efficient to support children with special needs, e.g. children with German as their second language.

One important result is that the quantity and quality of writing products is much higher within the NIMIS classroom, i.e. by using the T^3 application, than in the normal classroom situation. Especially those children who are scared of writing take an advantage by using the T^3 application and its text to speech synthesis of the written content. Here they can try out independently the composition of phonemes without the direct observation of the teacher (this happens automatically in the normal classroom situation when the teacher reads out the writing of a child). Afterwards the data logging of the activities within the NIMIS classroom (e.g. starting an application, dragging a phoneme into the T^3 workspace) is visualised as a tree of HTML documents (see Fig. 10). This view gives the teacher a comprehensive impression of ongoing activities, thus enabling the supervision of the children's achievements.

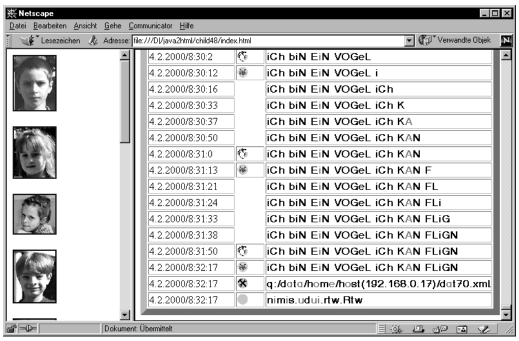

Fig. 10. Visual log from NIMIS activities

In *O Nosso Sonho*, the CiC environment has been installed since middle March and the first results showed that children were very keen to use it and becoming very skilful with it. These opinions are expressed by their comments about *Teatrix*:

- It's funny, instead of doing the drawings to use in the story we can pick them from a list of characters, props and scenes and in the end we build the story
- It's a fantasy of heroes and princesses. It's entertainment in the computer!
- *Teatrix* is a like a theatre, where we can play together. What I like most is the feeling of being inside the characters. In Teatrix we can do things that all others can watch, and that is very important because by this way everybody can participate in the stories.
- Is for us to do theatre.

Despite their positive opinions, they have also demanded for: more scenes, more props, more characters and also a higher level of control over the story characters. To fulfil these needs a new tool is being integrated in the system.

6. Conclusions

We are convinced that the NIMIS experience practically demonstrates the viability of new forms of integrative technological support in a whole classroom, yet subordinate to grown pedagogical methods. It supports a mix of natural and technologically mediated forms of collaboration and of classroom information management. The role of teachers is explicitly defined and particularly reflected in the software tools. A seamless transition from the traditional classroom to the CiC could be observed as well as an increased productivity in both quantitative and qualitative terms.

7. Acknowledgements

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