ASCIT SICK CHILDREN
AGAIN AT MY SCHOOL BY FOSTERING COMMUNICATION THROUGH INTERACTIVE TECHNOLOGIES FOR LONG TERM SICK CHILDREN

F. Di Fiore, P. Jorissen, F. Van Reeth
Hasselt University
Expertise Centre for Digital Media - IBBT
transnationale Universiteit Limburg
Wetenschapspark, 2
BE-3590 Diepenbeek (Belgium)
{fabian.difiore, pieter.jorissen, frank.vanreeth}@uhasselt.be

E. Lombaert, M. Valcke
Ghent University
Dept. of Education - IBBT
H. Dunantlaan 2
BE-9000 Ghent (Belgium)
{evelien.lombaert, martin.valcke}@ugent.be

G. Vansichem
ANDROME NV
Wetenschapspark, 4
3590 Diepenbeek
Belgium
gvansichem@androme.com

P. Veevaete, L. Hauttekeete
Ghent University
Dept. of Communication - IBBT
Korte Meer 7/9/11
9000 Ghent (Belgium)
{pieter.veevaete, laurence.hauttekeete}@ugent.be

Abstract
In this paper, we present the design, development, implementation and evaluation of a virtual learning environment that supports the learning process of long term sick children. We envision a solution that helps to establish high quality involvement of these children in a communication based scenario between the place where the child stays/has been moved and the original classroom/school setting. The system that we developed is based on concrete user needs, and is therefore assumed to be educationally sound and relevant. Furthermore, the solution is scalable and affordable as compared to previous ICT-based tools for this user group. To this end we incorporate innovative hardware, software and connectivity features, set in a user friendly user interface based on 3D technologies. The evaluation of the prototype reveals that our system increases social contacts, the amount of curriculum subjects participated in, and the variety in didactical strategies used.

Key Words
E-Learning, E-Health, Edutainment, Collaborative Learning, Virtual Learning Environment, Virtual Interactive Communities

1. Introduction

Motivation. During the last decades, health care has moved from an "intra muros" experience (hospital-based) to a rather "extra muros" treatment. While patients used to be hospitalised for extended periods in the past, currently the hospitalisation periods are much briefer and treatments are increasingly carried out at home. When children are involved, this evolution not only affects health care, but also education: the responsibility to provide long-term and chronically ill children with education shifts from the hospitals to the school which the children attended before school absence. Regular schools, however, are hardly able to set up high quality instruction for their home-based pupils. Fels, Shrimpton and Robertson stress the importance of regular school attendance and swift school re-entry with regard to the coping of the child with hospitalisation and illness management [1]. Unfortunately, most efforts focus on the re-entry of the child in the community and school rather than pre-empting this process by bringing the community and school to him [2, 3, 4].

Hence, our aim is to re-establish the communication link between sick pupils and their regular classrooms with regard to the improvement of instruction and social contacts during periods of school absence, not only at the moment of school re-entry.

Contribution. The present paper aims at clarifying the design, development, implementation and evaluation of an ICT-solution that is assumed to help establishing high quality involvement of the long-term and chronically sick children in a communication-based scenario between the place where the child stays/has been moved and the original classroom/school setting. The conceptual model of Passerini and Granger [5] and the IDI-model for instructional design [6] were used as guiding frameworks for the design process. Through an iterative process five steps were undertaken: (i) analysis of user needs, user characteristics and context factors, (ii) design (according to a functional analysis), (iii) development, (iv) evaluation, and (v) delivery.

We balance the choice for high end solutions with the need to develop a scalable and affordable solution. It has to be stressed that we do not develop an electronic learning environment (ELE) such as Blackboard, WebCT, Anywize, etc. or a content management system (CMS).

Approach. Following the design model of Passerini and Granger [5] we started with the identification of children's and teachers' (end users) needs. These findings were completed with the needs felt by significant others in the environment of the child (e.g., parents and health care professionals). Semi-structured interviews were conducted from seven long-term or chronically ill elementary school children. The interviews were conducted at the child's home or at the hospital, took approximately one hour and Mauthner's suggestions on data collection with children were taken into account: e.g., the children were interviewed privately [7]. Pictures and drawings were used to concretise the questions, as suggested by Borgers, De Leeuw and Hox [8]. The interviews were transcribed and analysed by two independent coders in a systematic way, using the constant comparative method [9]. Furthermore, 24 parents and 25 teachers who were confronted with such a child during the past three school years completed a survey. Finally, ten two hour observations

of individualised instruction moments at home or at a hospital school were conducted. Each observation was video-taped and completed with field notes.

Audiovisual data and field notes were analysed in a qualitative way. First, a number of findings concerning educational aspects were extracted, based on the instructional model of Valcke [10]: learning objectives, subject matter, instructional media, didactical strategies, and assessment. Second, special attention was paid to analysis of the way computers and other IT-equipment are currently used.

According to Passerini and Granger [5] we subsequently designed two ICT-solutions fulfilling the needs found in the first development phase. By means of semi-structured interviews the functional requirements according to these needs were determined. The same seven children and eight teachers were interviewed during approximately one hour. The third development phase distinguished by Passerini and Granger was the actual development of the ICT-tools: a virtual learning environment consisting of a virtual community [11] in which pupils that are absent from school due to health-related problems are still 'telepresent' in their regular classroom. This is based on the assumption that children of elementary school age are likely to prefer non-abstract environments with a limited amount of textual cues [12]. Therefore, a 3D visualisation of the child's classroom was chosen as it creates a more explorative, pleasant atmosphere. Furthermore, to initiate intuitive and natural interactions, it is assumed that a learning environment has to support communication, authentication, personalisation and presence [13] which corresponds to navigating in present-day games and on-line communities and, therefore, is assumed to fit in with their living environment.

Before the final stage of delivery of an integrated solution as described above, prototypes will be evaluated with regard to educational, social and technological variables. Therefore, case studies will be conducted during the school year 2006–2007. Six children, complying with the above mentioned criteria, will be given the opportunity to work with one of the prototypes during approximately one month. Interviews with children, teachers, parents and classmates before, during and at the end of a trial period, at least two observations at the child's end of the application, a brief questionnaire administered by the teacher on a daily basis and a stimulated recall interview of the children will give insight into the way all people involved use the tool and think about it. All data will be audio or video taped and will be transcribed. Two independent researchers will test analytical statements for each case in the way Bassey [14] suggested. The technique of stimulated recall interview is used to test the usability without interrupting the lesson the child attends, which would not be possible using the think aloud method [15]. Although this technique is often used to examine meta cognitive thoughts of teachers, it proves to be relevant to gain insight in the cognitive processes of high school students [16] and even young children [17].

2. Strengths and Weaknesses of Related Work

To date, a variety of solutions, based on the integrated use of information and communication technologies (ICT), has been developed and implemented in several settings. Unfortunately, a systematic evaluation of these attempts is often lacking.

The most well-known example is provided by PEBBLES (Providing Education By Bringing Learning Environments to Students), an advanced prototype solution developed in the USA and

Canada [18]. It was launched as the world's first fully functional 'telepresence' application: a social and technological solution that virtually places a child within the classroom by putting a robot in the regular classroom. According to Fels and colleagues [19] the playful form of PEBBLES creates a social dynamic between the children in the classroom and the remote student that is very different from that which would be achieved with an impersonal video monitor. In addition to these self-stated advantages, some weaknesses were discovered with regard to the PEBBLES-solution. For example, no information was found in the available literature on the opportunities of asynchronous learning. Furthermore, moving back and away from hospital or home or moving from one classroom to another is assumed to cause interruptions or even an impossibility to continue the instructional experience. Another critical issue evidenced by empirical exploration in the field, is the high cost of developing and maintaining the PEBBLES-provision.

A second remarkable ICT-tool to support children with health impairments is STARBRIGHT World (SBW), an online community where these children can connect to each other. Children on SBW can chat, read and post to bulletin boards, email, search for friends with similar illnesses, participate in fun events and contests, surf pre-screen Web sites and play games [20]. Further analysis of the available papers on the use of SBW, however, pointed out that the communicative possibilities were seldomly used by the children: only 3% to 15% of the time was spent on communication [21].

In Flanders, the Dutch speaking part of Belgium in which our study is carried out, a type of video phone is already in use to support long term sick children to stay in touch with their family and peers at school [22]. However, an introductory empirical exploration revealed that hospital staff members experience some problems with these tools: for example, there is an asynchronous delivery of sound and images, they offer basic video connection capabilities of rather low quality and if it is often used, it is a rather expensive solution due to the payment per minute of talking.

Besides the use of this video phone device, the use of electronic learning environments (ELE), through which the school, parents and pupils get in touch more regularly, are increasingly promoted. However, these tools build heavily on text-based input. Therefore they are assumed to be less suited for pupils of elementary school age. Furthermore, we believe that traditional electronic learning environments fail to support active interaction between the end-users.

3. User Needs and Task Analysis

Despite the rather small group of children involved in the study, the purposeful sampling procedure ensures a considerable amount of variety with regard to some characteristics which were thought to be relevant. Table 1 shows some important characteristics of the participating children.

Needs were analysed with regard to two major processes in children's lives offered by schools: socialisation opportunities and instruction. With regard to the current socialisation opportunities of the participating children, we found that social activities such as playing and cycling together to school and back were the things they missed most during periods of school absence.

With regard to current instructional experiences, most of the participating children indicated to miss the experience of being taught in a classroom environment. They stress two considerable differences between instruction at home or at the hospital and class-based instruction: the subjects

Table 1: Variety in participant characteristics.

Child	⚥	Age	Type of illness	Type of school absence
1	♂	12	Chronic metabolic disease	Frequent, short periods
2	♀	8	Chronic skin disease	Frequent, short periods
3	♀	11	Cancer	Continuous period
4	♀	9	Leukaemia	Continuous period
5	♀	11	Cancer	Continuous period
6	♀	12	Cystic fibrosis	Frequent, short periods
7	♂	8	Brain tumour	Continuous period

Table 2: The official Flemish curriculum subjects and which of them are being taught during the child's school absence. The asterisks (*) in the table represent the subjects the same children reported as the three (or less) subjects they miss most.

Child	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Dutch	X	X	X	X	X	*	X
French (from 10 years on)	X		X		X	*	
Mathematics	X	X	X	X	X	*	X
Religion				*			X
Social studies	X	X	X	*	*		X
Handicraft & Music	X	*	X	X	*		X
Gym		*	*	*	*		*

(learning content) and the didactical strategies differ. As for learning content, table 2 depicts the official Flemish curriculum subjects and which of them each participating child is being taught during their school absence.

Most children are taught the main courses and miss the courses they can no longer take, specifically gym. Only the girl who was not instructed at all (table 2, child 6), missed the main courses. This indicates that instruction is very important for children in one way or another, even if they are not able to attend school. The same goes for didactical strategies: the interviews with children, the surveys of teachers and the observations point out the unbalanced proportion of individual didactical strategies as compared to group-based didactical strategies.

In sum, we can state the most preliminary needs found were (i) to improve the socialisation opportunities which children usually experience at school by offering them the opportunity to communicate synchronously and without go-between such as teachers or parents, and (ii) to supplement the current instruction these children have at home or at the hospital, in particular with regard to curriculum subjects and didactical strategies.

4. Functional Analysis

The functional analysis examined the translation of these needs into technology design requirements. Teachers were asked to identify an activity they did recently and in which they would have liked the sick child to participate by means of an ICT-device. Most of them would use the tool for project-based classroom activities. Within these projects, they would use the ICT-tool most for practical, hands-on activities, such as creating an exhibition and performing energy experiments. These practical activities are most of the time group-based.

Furthermore, some of them would use an ICT-device for non-practical group activities, such as a group conversation and a meeting in order to accomplish a project. Less, but still a few teachers would also use an ICT-device for individual tasks and instruction. These results are in line with the needs for more group-based didactical strategies reported by the participating children. With both groups of end-users (children and teachers) we searched for technical requirements the ICT-device has to meet, to fulfil these needs. The most important findings and related requirements are:

(i) When children were asked what they would look at using an ICT-tool, most of them answered "my friends", followed by "the teacher". Furthermore, some teachers point out the significance of audio quality, for example to follow a group discussion.

(ii) All participants showed a positive attitude towards the communication opportunities offered by ICT-use. Hence, the synchronous requirements for both formal and informal contacts were studied in greater detail. As for formal contacts during lessons, a remarkable finding is that almost half of the children and all teachers want to have the opportunity of passing on notes, work pages, etc. in the most appropriate way. As for informal, social contacts most participating teachers and children believe requirements formulated regarding formal instruction are enough to fulfil the social needs.

(iii) Half of the children and more than half of the interviewed teachers also hope some asynchronous functions will be available. They want a storage place in a secure internet environment to post all kinds of messages.

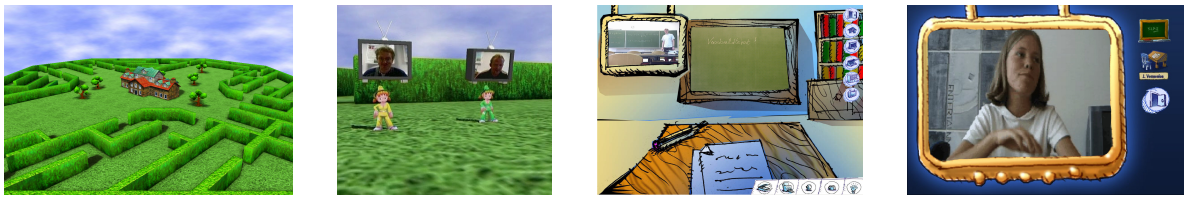
5. Virtual Learning Environment

The virtual learning environment that we developed consists of a virtual community that can be shared by many users including the sick pupil, the teacher and the fellow pupils.

5.1 Virtual Interactive Community

Virtual Communities (VC) are defined as communities of people sharing the same interests or ideas who are remotely present through the internet [11]. The virtual learning environment we develop consists of a 3D virtual community in which chronically ill pupils are still 'telepresent' in their classroom.

Children of elementary school age are assumed to prefer non-abstract environments with a limited amount of textual cues. Therefore, a 3D visualisation of the child's classroom was chosen. It lends a more explorative, fun atmosphere to the learning environment. Interaction within this environment is assumed to be intuitive and natural, therefore, the virtual environment should support *communication*, *authentication*, *personalisation*, and *presence*.



(a) (b) (c) (d)

Figure 1: Snapshots of the virtual learning environment. a) View of the entire world. b) The use of video stream texturing on animated avatars. c) Example view of the classroom as seen by the pupil. d) View of the pupil as seen by the teacher.

5.1.1 Virtual World

Upon starting the tool, the user automatically ends up in the 3D virtual environment. Taking into account that the community is children-oriented, all its objects are created in cartoon style (see fig. 1).

Navigating in this virtual world happens by means of a graphical personification of the user, also called an *avatar*. This corresponds to navigating in present-day games and on-line communities including (but not limited to) 'Ice Age 2' and '(Teen) Second Life' and, therefore, is assumed to fit in with their living environment.

The environment also provides for *community support functions* like buddy lists (with classmates, teachers, parents), authentication and authorisation functionalities providing the pupil with the same level of privacy, and rich presence (showing who is online, which mood he or she indicates to be in, what kind of activities one is pursuing).

To respond to the need of the end users for synchronous communication, we integrated several synchronous communication components into the environment including audio conversation, video conferencing (with remotely controllable web cams), text chat and video-based avatars [13], illustrated by fig. 1(b).

5.1.2 The Pupil in the Virtual Classroom

By navigating through the virtual world and the school, pupils can enter the virtual classroom. Unlike the rest of the world, the classroom is represented by a fixed and static 3D view containing the most important elements of a real classroom, shown in fig. 1(c).

These elements are a *live video view of the class* (top, left), a *captured image of the blackboard* (top, middle), the pupil's *school desk* (bottom), and the pupil's *personal bookshelf* (top, right). Furthermore, several function buttons allow the sick child to (i) quickly launch specific tasks such as scanning, transmitting or printing documents, (ii) capturing the blackboard, (iii) drawing attention, and (iv) jump to predefined views such as a close-up view of the blackboard, the personal bookshelf, the opened school desk and the live view of the classroom. In order to make the room more attractive or live-like other content can be shown as well, e.g., posters or leaflets to learn vocabulary, an agenda, a notice board and pictures of the fellow pupils.

Communication between the pupil and the class happens through video-chat (i.e. video instant messaging between two or more people, analogous to using a teleconferencing system). Consequently, the pupil has to be equipped with a webcam and microphone. In our system, a pupil always can ask for attention: pressing a button at the child end of the tool will flash a light and play a sound at the classroom end.

In order to exchange homework and corrections, a scanner and a printer are present at both ends of the tool. By clicking only one virtual button, homework and corrections can be printed, scanned or transmitted automatically. This is explained further in Section 5.2.

5.1.3 Teaching in the Virtual Classroom

Analogous to the pupil the teacher can enter the virtual classroom by navigating through the virtual environment. Contrary to the pupil's interface, less input is demanded from the teacher in order to not distract him/her from the regular teaching process (see fig. 1(d)). Consequently, audio and video-based techniques are employed as much as possible. At the classroom end of the tool, the function buttons are similar to the buttons at the sick child's end. In addition, the teacher has the possibility to capture and transmit the current content of the blackboard and record an audio/video message or even a part of a lesson.

5.2 Functional Aspects

This section discusses the functional aspects of our virtual learning environment corresponding to the requirements described in Section 4.

5.2.1 Following Lessons Synchronously

One objective of our work is to re-establish the communication link between the sick pupils and the regular classroom. Consequently, two issues should be considered: (i) the pupil should be able to follow the class activities simultaneously with the fellow pupils, and (ii) the pupil himself/herself should be virtually present in the classroom.

In our system, the first issue is tackled by employing a microphone and one (or more) (controllable) webcams which are mounted in the classroom. By doing so, the pupil can watch the general instruction offered by its own teacher as shown in fig. 2(a). Whenever more detail is needed, for instance important information is written on the blackboard, the pupil or teacher can take a high resolution snapshot (fig. 2(b)) pushing only one button.

Regarding the second issue, the child's setup is also equipped with a webcam and microphone in order to be heard and seen by its classmates and teacher.

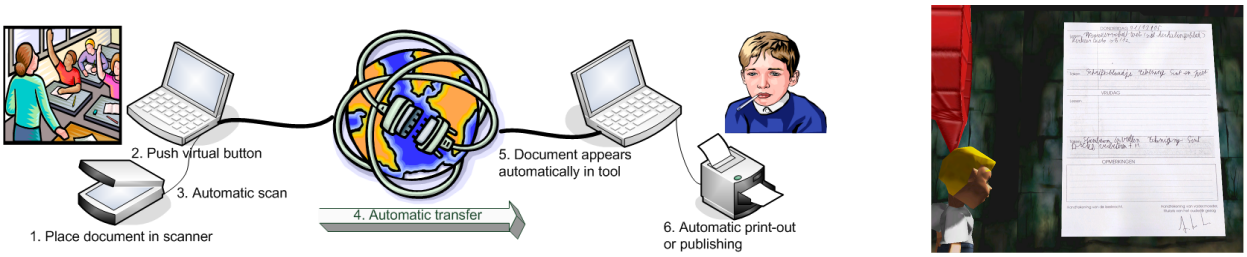
5.2.2 Diary and School Timetable

In our system, the teacher can automatically transmit/publish a diary or a school timetable (see fig. 3(a)). The scan function allows a teacher without a digital agenda or schedule to do so too.

(a) (b)

Figure 2: a) Live view of the class as captured by the webcam present in the classroom. b) View of the blackboard. The inner part is a snapshot of the physical blackboard, taken by the digital camera or webcam present in the classroom.

Transmitted documents can be printed-out automatically and/or published in the virtual world. Furthermore, the print and scan functions allow the child to print the schedule and scan it again, indicating which courses he or she is planning to follow synchronously. Fig. 3(b) depicts a sick child (represented by its avatar) consulting his timetable.



(a) (b)

Figure 3: a) Automatic scan, transfer, and print-out/publishing. b) 'Avatar' consulting a diary published in the virtual world.

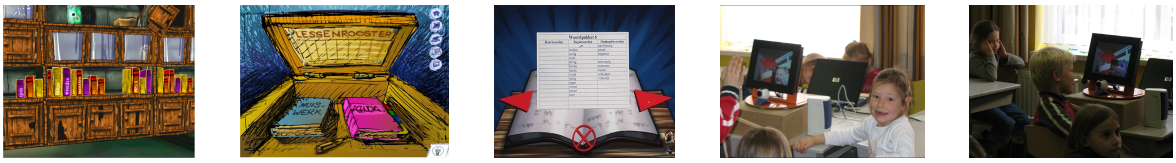
5.2.3 Homework, Exercises, Tests and Marking

In a similar way as transmitting/publishing a diary, the sick child can make homework and exercises or perform tests. First, the teacher sends the assignment. Then, the sick child accomplishes the assignment. The possibility of doing this at the same moment that the fellow pupils do it, is assumed to increase the feeling of being present in the class. Finally, the pupil sends the completed assignment back to the teacher.

Besides making assignments, getting feedback is also an important issue for pupils. Our system offers the teacher the opportunity to correct these assignments on the printed version in the same way the assignments of regular pupils are corrected. Subsequently, with one click the corrections are sent back to the pupil using the system. If needful, video-chat can be used to provide complimenting face-to-face feedback.

5.2.4 *Asynchronous Possibilities*

The user and the functional analysis pointed out that not all sick children will be able to follow all classes virtually due to health related constraints. Consequently, we have to provide a way for exchanging information asynchronously as well.



(a) (b) (c) (d) (e)

Figure 4: a) Class library used to store *public* virtual books. b) Pupil's personal desk containing *personal* books like diary and homework. c) Thumbing through a virtual book. d–e) Classroom-present tool.

Our solution employs the metaphor of virtual books to store and retrieve information asynchronously. We distinguish between two types of virtual books: (i) *public* books which can be created or read by any user (e.g., to share pictures of the latest field trip), and (ii) *personal* books which only can be created or read by the sick child and the teacher (e.g., diary and homework) (see fig. 4(a–c)). In other words, the teacher can publish documents in one of the available books (public or personal) at any time. The sick child, at his/her turn, can wait until any convenient moment to consult the content.

5.2.5 *Social Function*

The user analysis revealed that the involvement in informal activities at school are at least as important as being involved in formal activities. In particular, children indicated they miss the socialisation opportunities offered at school. Therefore, our system has to create a communication link between the sick pupils and their regular classroom with regard to supporting social presence.

All functionalities mentioned earlier can contribute to this aim. Most teachers and children interviewed, indicated that the synchronous functions of audio and video chat are enough to fulfil the social needs (e.g., people can share personal media (pictures and video) within their own community of interest). On top of this, we built a *classroom-present* device as well in order to foster social inclusion in the classroom as much as possible. The main design philosophy of this hardware device has been on giving a general feel of presence of the remote child in the classroom (fig. 4(d–e)). It consists of an LCD screen (used to depict the sick child) and a webcam which both are attached onto a servomotor. Using a simple game controller, the sick child can rotate the device in order to look around.

In addition, a few children indicated they would like to 'play' within the virtual world. Therefore, in our system the opportunity to play is supported by means of lifelike party games and links to online games, all set in a playful environment.

5.3 Network Architecture

The following subsections describe all tasks and different responsible servers which make up the underlying network architecture of our system.

5.3.1 Tasks

In accordance with the functional aspects four different tasks can be distinguished.

Upon starting the software, *Session Management* comes into play. It mainly is responsible for logging on/off users and taking care of authentication. After logging on, the user can navigate through the virtual world by means of an avatar. At any moment, all users are being informed of each other's presence (i.e. position, mood (as indicated by the user), activity, ...) but also of any obstacles in the world. This is managed by *VIC Interaction Management*. *Communication Management* is responsible for distributing multimedia content in synchronous mode (e.g., video-chat, attending classes). Finally, *Data Transfer Management* handles the transportation of data in asynchronous mode (e.g., file transfer, audio/video mails).

5.3.2 Servers

All tasks are being handled by four servers. The division into different servers is done for logical reasons only; in practice all different servers can be run on only one machine.

The *session server* takes care of logging on/off and authenticating users. In addition, it is also being used to initialise A/V communication sessions and to set up file transfers. Whenever synchronous communication is needed between two parties, audio and video can be exchanged peer-to-peer. However, this is not feasible when multiple parties are involved due to the limited bandwidth. To solve this, one single stream is sent to the *communication server*, which relays it to the different parties. The session server is responsible for indicating which communication server to use. The *VIC server* takes care of the entire 3D virtual environment. This involves transmitting the world itself, synchronisation between the clients and always storing a persistent world. The *data server* is used for two categories of asynchronous data. On the one hand, it stores configuration files of the users containing personal information such as A/V parameters and address lists of the community. On the other hand, the server makes it possible to transmit and store (shared) media and files in asynchronous mode.

6. Results

In this section we elaborate on the results of the field trials.

6.1 Field Trials: Evaluation of the Prototypes

In order to evaluate our system, five field trials have been set up with the future target audience within authentic settings. Table 3 represents some child characteristics.

Table 3: Characteristics of the children participating in the field trials.

Child	Age	⚥	Illness	School attendance during field trials	Proto-type	Use	Trial
1	9	♀	Chronic skin disease	Yes, half days	1	Only once	October–December, 2006
2	15	♂	Traumatic brain injury	No	1	Daily	March, 2007
3	13	♂	Chronic metabolic disease	Yes, a few times	2	3 days/week	January–March, 2007
4	12	♀	Surgery recovery	Yes, increasing	2	Daily	April–June, 2007
5	11	♂	Leukaemia	No	2	2 times/week	April–June, 2007

The participants were said to make use of the prototype in the way they believed it to be relevant and applicable. Two major research questions are as follows:

(i) In what way was the prototype used for socialisation and which social outcomes were reported by the participants?

(ii) Did the use of the prototype provide a larger amount of variation with regard to (a) subjects and (b) didactical strategies as compared to the learning contents of their home of hospital based instruction?

Despite some obstacles (i.e. connectivity and technical problems), the application was used at least three times (case 5) and in case 2, 3 and 4 it was used daily. Table 4 summarises the main findings with regard to the first research question.

In all cases, the tool was used for socialisation purposes. Only the oldest kids (child 2 and 3) used it many times and initiated these contacts once in a while. Furthermore, in most cases the available synchronous functionalities of the tool were used to do so (except for case 4). In cases 2, 3 and 5 an increase in social contacts was reported. As the girls in trial 1 and 4 were able to attend school on a daily basis (e.g., in the morning) during the trial, the tool might be more important with regard to socialisation opportunities for children being absent at school for longer periods in time.

Table 5 summarises the findings with regard to research questions (ii.a) and (ii.b).

The ability of the tool to offer more variety in curriculum subjects seems to be related to the availability of main subjects in home or hospital education. The tool was predominantly used for main subjects in all cases, however, in the case with primary school children (case 1, 4 and 5) courses are added to the core curriculum of homebound instruction by using the tool.

In most cases, the use of the tool offered the participating child an increase in didactical strategies used as compared to the amount of strategies used in home or hospital education (case 1, 2, 3 and 5). In case 4 not the features of the tool, but the ignorance of the teacher led to a narrow use of the tool in terms of didactical strategies. However, in cases 2 and 3 the teachers did not positively evaluate group-based strategies using the tool. This was due to problems with class management (case 2) and technical problems such as the limited quality of audio stream to follow a class discussion (case 3).

Table 4: Summary of results with regard to the first research question: the use of the tool for increasing the socialisation opportunities.

Child	In what way was the tool used for socialisation activities?	What social outcomes were reported?
1	It was used only once for socialisation. The girl and her classmates showed each other the craftworks they had made. The activity was initiated by the teacher.	The child enjoyed this activity as she felt 'what was going on in her classroom'.
2	It was used once for an off-task talk with former classmates during a school break. The classmates initiated this activity. Furthermore, the minutes between two courses were often used to chat.	Although the child looked forward to talk to his formal classmates, ten minutes after starting the talk, they didn't know what to say anymore. The short chats were evaluated positively by both the child and the participating teachers.
3	Sometimes, the classmates were given a few minutes 'free' to talk to the sick child. Both the classmates and the sick child initiated this activities once in a while and again the synchronous features of the tool were used.	The boy's mother said that the feeling of 'belonging' increased during the trial period. As compared to earlier periods of long-term school absence, the boy was able to maintain contacts more easily.
4	The computer, on which the software was installed, was used to interact with classmates during breaks. However, instant messaging was used instead of the synchronous functionalities of the prototype.	As the majority of expectations, uttered by the child and its mother at the start of the trial period, focused on formal instruction, no information on the effect of using the prototype for better maintaining contacts was gathered.
5	The prototype was used once to interact with friends. The synchronous functionalities of the tool were used to do so and the chat was initiated by the teacher.	Both the child and the teacher reported an increased feeling of 'belonging'.

Table 5: Summary of results with regard to the second research question: the use of the tool for increasing (ii.a) the variety in curriculum subjects taught and (ii.b) the didactical strategies used.

Child	Effect on the variety in curriculum subjects?	Effect on the variety in didactical strategies?
1	The tool was only used once, for social studies. Both the teacher and the child enjoyed this lesson. However, the teacher was not really convinced with regard to the relevance of using the prototype for formal instruction.	The only strategy in which the child was involved using the prototype was a class-based reading task in which each child had a specific role.
2	The tool was used for Mathematics, French and Latin, which are main curriculum subjects. However, Latin was not provided by the hospital school, which means an increase in curriculum coverage by the tool. The participating teachers found the tool less useful for his French course due to the large variety of didactical strategies used in this course.	The prototype was used most for instruction by the teacher, a didactical strategy which is also common in home-based or hospital education. Only during the French course it was used for other didactical methods such as a class discussion and a group work.
3	The boy participated in Dutch, Mathematics and Trading Sciences classes by using the tool. These are the courses he always takes at school and that are not provided by home education in periods of long-term school absence. Therefore, the tool increases the amount of courses the boy can participate in.	The tool was used for individual strategies also used in home education (e.g., instruction by the teachers and individual task completion) as well as for group-based strategies such as class discussions and an interactive class-task. In sum, the boy was involved in a greater amount of strategies as compared to the period before the field trial.
4	This girl participated in all curriculum subjects, with a focus on the main subjects: languages and mathematics. End interviews with the mother and the child revealed that the opportunity to use the prototype contributed to keep up with mathematics, which only home instruction could not.	The tool was predominantly used for instruction by the teacher and individual tasks, the strategies often used in home education. Once a group activity was planned, but the child was not allowed to participate.
5	Again, the tool was used for main curriculum subjects: Dutch, mathematics and social studies. The boy did already have an overwhelming scheme of education-related activities at the onset of the trial period. Therefore, the use of the prototype did not really offer more variety in curriculum subjects.	Although the tool was predominantly used for individual strategies common in home education, it was also used for class discussions and educational play. The use of the prototype did offer more variety in didactical strategies as the child was able to take part in class-based activities and group strategies again.

6.2 Hardware Recommendations

In the classroom, a *digital camera* is employed in order to take snapshots of the blackboard. The results clearly indicate (i) to use a resolution of 1600 x 1200 pixels (i.e. 2.1 Mpixel), (ii) to avoid using the flash, (iii) that colours look better on a blackboard than on a whiteboard, and (iv) to use a camera that can be controlled by software. Regarding the *webcam*, a resolution of 320 x 240 suffices to have a decent view and frame rate (25fps). Tests also pointed out that it is even possible to capture a film that is shown on the classroom television. Concerning audio, the pupil easily can make use of a headset or the *microphone* integrated into the webcam. The teacher is advised to use a wireless microphone together with fixed speakers. This requires the need for acoustic echo cancellation (AEC), either incorporated in the microphone or in the software. Finally, the personal computer itself only needs to have a 3D accelerator graphics card in order to fluently visualise the 3D environment.

6.3 Network Capacity

Regarding bandwidth, the real bottleneck is streaming live audio and video. Our tests pointed out that when using the H.263+ codec [23] for compressing video (comprised of 320 x 240 pixels at 25Hz), 128kb bandwidth is needed. This is quite acceptable as most people and schools in the Flemish setting own a xDSL or cable connection (download speed: 4.4–6Mb, upload: 192–256kb).

7. Recommendations for Future Research and Development

In the near future, a second iteration of the field trials is planned taking into account all the above mentioned recommendations. The evaluation phase of the first iteration revealed some problems in technique and in connectivity. The current prototype will be improved in the second iteration field trials. Furthermore, the first iteration evaluation revealed some important preconditions which have to be fulfilled to contribute to a successful trial, such as a positive teacher attitude. In addition, future evaluations will also focus on several relevant outcomes, such as the effect of having an ICT-tool on the experiences of children when re-entering their school, the academic achievement and psychosocial outcomes (e.g., well being, coping and social adjustment).

8. Conclusions

Existing ICT-based solutions to foster communication for long-term and chronically ill children primary focus on the re-entry of the child in the community and school rather than pre-empting this process by bringing the community and school to this child. Furthermore, these existing solutions have weaknesses such as the absence of applications to support informal contacts rather than formal instruction and the high cost of developing.

We tried to design a system which is based on concrete user needs, which is educationally sound and relevant for supporting both formal and informal processes, and which offers a scalable and affordable solution. Although weaknesses appeared within the first iteration of the design process,

we assume it comprises a technical solution that will help to establish high quality involvement of the long term sick children in a communication-based scenario between the place where the child stays/has been moved and the original classroom/school setting. The first evaluation of the prototype revealed that the system increases social contacts, the amount of curriculum subjects participated in and the variety in didactical strategies used.

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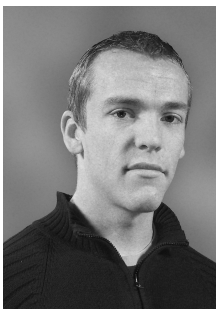
Prof. dr. Fabian Di Fiore is a senior researcher in computer science at Hasselt University (UHasselt) in Belgium and a professor of Didactics of Computer Science at the University of Antwerp, Belgium. He obtained a MS in computer science in 1997 at the University of Leuven. In 2004, he finished his PhD entitled "A 2.5D Modelling and Animation Framework Supporting Computer Assisted Traditional Animation" at the Expertise Centre for Digital Media (EDM), a research institute of Hasselt University. His research interests are computer animation, non-photorealistic rendering and highly stylised drawn animation.



Pieter Jorissen is a PhD candidate in the Department of Computer Science at the Hasselt University (UHasselt), Belgium. He received his BS and MS degree in computer science from the Limburgs Universitair Centrum in 1999 and 2001, respectively. He is now working as a research assistant at the Expertise Centre for Digital Media (EDM), a research institute of the Hasselt University. His current research interests are in the fields of virtual interaction, collaborative virtual environments, animation and physical simulation.

Prof. dr. Frank Van Reeth is a full-time professor of Computer Science at Hasselt University (UHasselt) in Belgium and Deputy Managing Director of the Expertise centre for Digital Media (EDM), a research institute of Hasselt University. He is co-founder of five spin-off companies and a member of the board of ANDROME NV. His research interests include computer graphics, computer animation, virtual environments, multimedia technology and telematics. He was project leader of several industrial contract research projects, technical representative in and project manager of various EC research projects.

Evelien Lombaert is a researcher at the research group Onderwijskunde (OWK), a research institute of the department of educational studies at Ghent University.

Prof. dr. Martin Valcke is currently professor Instructional Sciences at the Ghent University, Belgium and head of the Department of Education. His actual field of research focuses on the innovation of Higher Education and the integrated use of Information and Communication Technologies (ICT). He has been and is being involved in a large number of national and international research and consultancy projects. Next he is regularly involved in activities and projects of the World Bank, the European Commission, and other international organisations.

Gert Vansichem is a R&D Manager at Androme NV. ANDROME is the leading company of the ANDROME Group, a European group of dynamic ICT companies in Belgium and Spain. He received his BS and MS degree in computer science from the Limburgs Universitair Centrum and the Vrije Universiteit Brusssel, respectively. His current research interests are in the areas of telecom, information and management systems as well as e-business and interactive multimedia, computer graphics & virtual reality.

Pieter Veevaete is a researcher at the research group Media and ICT (MICT), a research institute of the department of communication sciences at Ghent University. He received his MS degree in communication sciences from Ghent University in 2002.

Dr. Laurence Hauttekeete is a senior researcher at the research group Media and ICT (MICT), a research institute of the department of communication sciences at Ghent University. She finished her PhD in 2004 at Ghent University. Her research activities are concerned with printed and audiovisual media, media-economics, new media, and qualitative and quantitative research methods.