Disruptive Devices: Mobile Technology for Conversational Learning

Mike Sharples

Kodak/Royal Academy of Engineering Educational Technology Research Group
University of Birmingham, Edgbsaston, Birmingham, B15 2TT

m.sharples@bham.ac.uk

Abstract

Learners can command an increasing range of mobile technologies that have the potential to support learning anytime anywhere, but also to disrupt the carefully managed environment of the classroom. This paper outlines a theory of learning as conversation that can provide a framework for the design of mobile networked technology for learning. It describes a prototype device based on a pen tablet computer with camera, phone and wireless LAN connection, combined with software to support learning actions, descriptions and conversations. Such devices raise both opportunities and challenges for classroom education.

Keywords

Wireless technology, mobile computer, conversational learning, mobile learning, computers in the classroom

Biographical notes

Mike Sharples is the Kodak/Royal Academy of Engineering Professor of Educational Technology at the University of Birmingham, UK, and Director of the University's Centre for Educational Technology and Distance Learning (CETADL). The focus of his research is the application of studies of human cognition and social interaction to the design of computer-based learning environments and personal technologies.

His current projects include the design of mobile learning technologies, a developmental study of children as photographers, a Lab of Tomorrow project to design wearable and embedded science experiments, the design of a knowledge-based training and decision support system for neuroradiology, the design of conversational learning environments for higher education, and computational story writing infomed by a cognitve account of the writing process.

1. Introduction

The history of computers and education has largely been confined to how computers can most effectively be introduced into the classroom. The substantial achievements include the introduction of multimedia personal computers into schools and colleges, their connection to the Internet, and the development of some imaginative and useful educational software.

Yet despite twenty years of research and investment, a report in 1999 from the UK Office for Standards in Education (OFSTED) stated that that in primary schools the average ratio of children to computers is 1 to 18 and that there are "acute problems in IT in 4:10 schools" [1]. In secondary schools there is little sign of the technology being used to support deep learning. Instead, computers are used mainly to teach basic IT skills such as word processing and spreadsheets. A 1998 OFSTED report on IT in UK secondary schools [2] concluded that there is "too much of a focus on the teaching of mechanical IT skills at the expense of higher order capabilities".

Rather than address the twin problems of instructional design and classroom management, this paper examines an alternative approach to computer-aided learning, based on personal wireless networked technologies. Such an approach was first proposed in the early 1970s by Alan Kay and colleagues at the Xerox Palo Alto Research Center [3]. They created concept models of a Dynabook, a handheld multimedia computer. They developed prototype desktop computers which they named "interim dynabooks" and implemented an object oriented programming language, Smalltalk, for educational applications.

Although Dynabook project had profound consequences for the computer industry, leading directly to the development of the desktop interface and personal networked computer, it never achieved its goal of enabling learning through interaction with "personal dynamic media". Not only were the researchers over-optimistic about the speed of technology development, but their aim of equipping learners with personal mobile devices conflicted with the prevailing emphasis on incorporating computers into classroom teaching.

The assumption that computer-mediated learning will occur in the classroom, managed by a teacher, is now being challenged, not by schools and educational software developers, but by the consumer growth of personal technologies. Many children already have access to a wide range of computing and communications devices. A UK survey in January 2001 by the NOP Research Group [4] found that 48% of children aged 7-16 owned a mobile phone and that on average they send 2.5 text messages per day. In another survey, in December 2000 [5], NOP found that 62% of all 7-16-year-olds were home Internet users, with 56% of these children using the Internet for homework and 43% for sending email messages. In the United States, a wireless networked handheld computer and communicator designed for teenage children is on sale for $99.95 [6]. It enables them to hold "walkie-talkie" voice conversations, send text messages and play multiplayer games with nearby devices

The response of educational institutions to such powerful technologies has, almost universally, been to treat them as a threat to be countered. The General Secretary of the National Union of Teachers summarises the reaction of teachers and school governors to children who bring mobile technology into the classroom:

> "Inconsiderate" use of mobile phones by pupils will see the gadgets combated in the same way as previous crazes, such as pagers and Gameboys. Mr McAvoy predicts governors will rule: "Mobile phones are not for use during the school day - particularly during lessons. It is not only the person phoning or being phoned whose education is being disturbed - it is the progress of the entire class." [7]

Their concern is understandable. Research into teacher effectiveness has shown that the teachers who produced the most gains in student achievement were those who were "well organised, managed student disruptions by monitoring behavior, and enforced rules in a consistent manner" [8]. Institutional learning depends on the classroom being a sealed environment, with all outside interventions being carefully regulated by the teacher.

2. Conversational Learning

A dilemma at the heart of networked learning is that learners can command an increasingly sophisticated set of communication and computing devices, which they are forbidden to use within formal education because they disrupt lessons and lectures. Meanwhile, schools, colleges and universities are starved of IT resources, and in many cases are failing to make best use of those resources they have. This section discusses how this dilemma might be resolved, through the design of mobile technology that could support effective learning within and outside the classroom.

There is no ready-made theory of personal learning, nor coherent set of empirical studies, that we can call on to inform the design of technology to support learning in multiple contexts over long periods of time. Jarvis et al. [9] provide a useful overview of behaviourist, cognitivist, social, experiential and socio-cultural theories relevant to personal and lifelong learning. We can start to address the issue in terms of 3 C's of effective learning: *construction*, *conversation*, and *control*. Effective learning involves constructing an understanding, relating new experiences to existing knowledge [10]. Central to this is conversation, with teachers, with other learners, with ourselves as we question our concepts, and with the world as we carry out experiments and explorations and interpret the results [11]. And we become empowered as learners when we are in control of the process, actively pursuing knowledge rather than passively consuming it [12, 13].

The description given here of learning as conversation is based on the work of Gordon Pask [11]. With a prescience that foreshadows recent developments such as the Semantic Web (the development of the worldwide web into a knowledge-based medium) and grid computing (pervasive computing power available like electricity on an international grid) Pask proposed a new conception of communication. Rather than seeing communication as the exchange of messages through an inert and transparent medium, he reconceived it as consisting of program sharing and linguistic interaction within a pervasive computational medium [14]. Thus, media are active computing systems within which mind-endowed individuals (people and intelligent systems) converse.

Pask's definition of a "mind" was broad, to encompass any organisation expressed in a mutual language (able to accommodate commands, questions and instructions) that gives rise to thought, feeling and behaviour. This includes human minds, but also some computer programs, and even theatre scripts and political manifestos. Minds, by expressing language and instantiating different systems of belief, provide the impetus for conversation. For example, a political ideology instantiates a system of language and beliefs which, when expressed in a party manifesto, gives rise to debate and discussion. On a smaller scale, two children with different views of a shared phenomenon such as a physics experiment, and capable of expressing their views in a mutual language, engage in conversation to try and come to a shared interpretation. Central to these learning conversations is the need to externalise understanding. To be able to engage in a productive conversation, all parties need access to a common external representation of the subject matter that allows them to identify and discuss topics.

Thus, the minimum equipment needed to hold conversations that promote effective learning consists of the following: a shared language in which to express commands, questions, instructions, agreements and disagreements; minds capable of giving rise to conversation about some shared phenomenon; and an external representation of that phenomenon that can provide a common framework for exploring differences of conception. Relating this to the design of learning technologies, we require more than transparent channels of communication and a means for transmitting knowledge, we also need a shared language (among learners, and between learners and computer systems), a means to capture and share phenomena, and a method of expressing and conversing about abstract representations of the phenomena. For further discussion of the relation of conversation theory to the design of learning technologies, see [15].

Conversation Theory describes learning in terms of conversations between different systems of knowledge. Pask was careful not to make any distinction between people and interactive systems such as computers, with the great advantage that the theory can be applied equally to human teachers and learners, or to computer-based teaching or learning support systems.

To describe how Conversation Theory can be applied to the design of learning technology, we begin with a person engaged in some activity in the world, carrying out an experiment perhaps, or solving a problem, or exploring an environment such as a park or museum. As the person performs the activity he or she tries out new actions, reflects on their consequences and makes decisions about what to do next (Figure 1). The person is actively *constructing* an understanding of the activities. There is continual interaction and adjustment between the person's thoughts and actions. Then, in order to gain from that experience, to perform it differently or better in future, the person needs to form a description of themselves and the activities, to explore and extend that description and to carry forward the understanding to a future activity. That is the minimum requirement for any person, or any system, to learn: it must be able to converse with itself about what it knows.

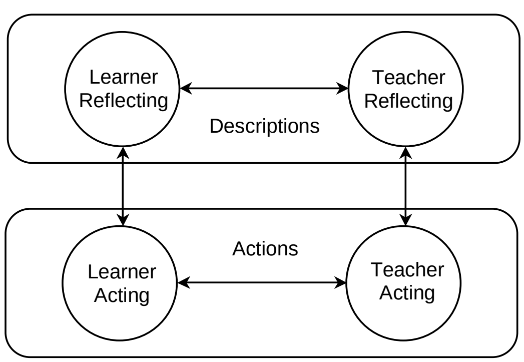

Figure 1. A framework for conversational learning

A more effective form of learning is when people can converse with each other, by interrogating and sharing their descriptions of the world. Assume that two people are working together on some project and sharing a language to describe the activity and a pool of descriptions (such as notes or results of an experiment). Figure 1 shows a student and a teacher but it could be two students. Both people are interacting with the world and conversing at the level of actions, through phrases such as "look over here", "what's this?", "do that". They are also conversing at the level of reflections, exchanging and questioning descriptions of their knowledge through utterances such as “this result doesn’t fit with the others” or “why did you do that”?

We can say that the two people share an understanding if Person A can make sense of B’s explanations of what B knows, and person B can make sense of A’s explanation of what A knows. Thus, it is through mutual conversation that we come to a shared understanding of the world. Learning is a continual conversation, with the external world and its artefacts, with oneself, and with other learners and teachers.

Successful learning comes when the learner is in control of the activity, able to perform experiments, ask questions, and engage in collaborative argumentation [16]. The interaction between learner control and success is complex. Successful self-management of learning comes as a result of developing competence and skill in learning how to learn, and this developing independence needs to be supported by teachers. Learning may also be effective when control is appropriately distributed among the learners through collaborative working within a shared environment.

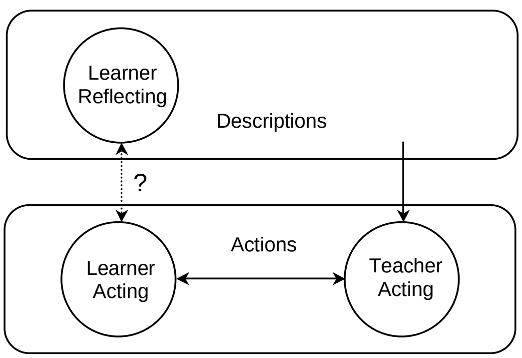

Figure 2. Computer-aided instruction

What place is there for technology within this conversational space? One possibility is for the computer to take the place of the teacher (Figure 2), as in traditional computer-aided instruction. The problem is that it only covers part of the conversational space. The computer can hold a limited dialogue at the level of actions: “look here”; “what’s this?”; “do that”, but is not able to reflect on its own activities or its own knowledge. Because it cannot engage in a conversation at the level of descriptions, it has no way of exploring students’ misunderstandings nor helping them to reach a shared understanding. Research in Intelligent Tutoring Systems has attempted to remedy this, but it is still at the stage of hand crafting individual systems and far from developing a computer that can converse freely about its own knowledge.

Alternatively, the technology could provide an environment in which conversational learning takes place; one that enables conversations between learners (Figure 3). It extends the range of activities and the reach of human discussion, into other worlds through games, software models and simulations and to other parts of this world by using the computer as a means of communication, through phone, email and computer based discussions. Children enjoy and seek this use of technology; it is exactly how they use mobile phones, computer chatlines and multiplayer games. The technology provides a pervasive conversational learning space.

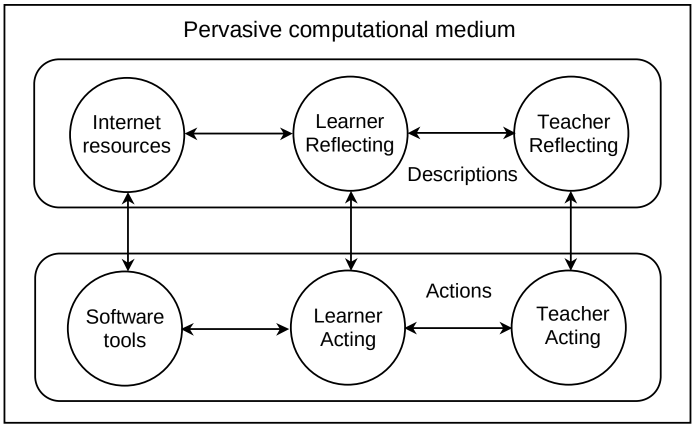

Figure 3. Technology for conversational learning

A mobile learning device can assist conversational learning by integrating learning descriptions across different locations, for example by making connections between exhibits in a museum, and by holding the results of learning actions for later retrieval and reflection. It can also provide tools to support learning in context, such as electronic measuring instruments, maps and reference guides. But if this powerful technology is carried into the classroom or the lecture theatre it can cause chaos. The students create links to the outside world, to a world of activities and conversations that they control, and that match neither the teacher's agenda nor the curriculum (Figure 4).

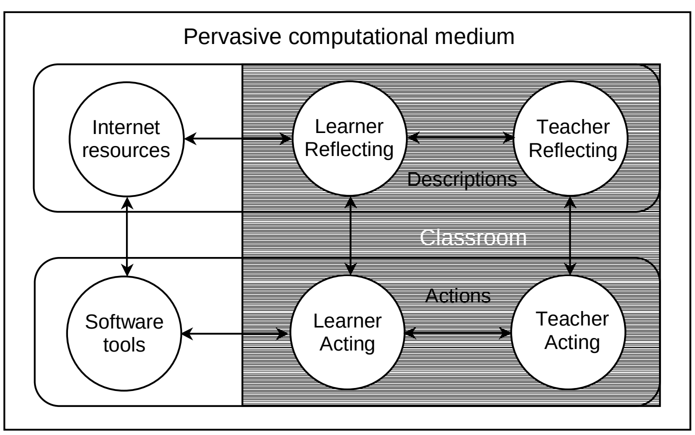

Figure 4. Computers and conversation in the classroom.

As educators we could take a number of stances. We could ignore the problem and hope it will go away. That is unlikely: the tensions between personal technology and institutional education will increase as students breach the sealed world of the classroom by bringing in computers that are capable of communicating with the Internet.

We could attempt to forbid it, but this just becomes a challenge for students to find new forms of conversation. It has already happened with mobile phones: forbidding their use in class has led to school students using mobile text messaging as a way of conversing behind the teacher's back, not just across the classroom, but to other classrooms, in other schools.

Or we can welcome students who bring their own personal communicators and computers, but in the full knowledge that they will disrupt traditional teaching and that this disruption needs to be managed. This is not an argument for technological determinism, for proposing that because students come armed with new technologies then education must adapt to accept them. There is a more defensible case for moving to more conversational approach to teaching and learning. The skills of *constructing* and exploring knowledge, *conversing* and collaborating with peers, and the ability to *control* one's own learning are fundamental requirements of effective learning. They are also skills prized by employers, as a Report by the Royal Academy of Engineering [17] makes clear:

> The 'self-reliance' skills usually mentioned as key [by employers] are negotiating, action planning, exercising judgment, networking, self-awareness and confidence. (p. 8)

Education has already started to move away from classroom-based teaching towards creating managed spaces for conversational learning that build on the students' own technologies, activities and resources. For example, some universities have connected halls of residence to the campus network, installed wireless LAN networks to enable students for students to connect their own laptops, and enabled students to carry share learning materials and converse online through managed learning environments such as WebCT and Blackboard. To extend this to include school level education will require a collaboration between teachers and learners, working together to create shared resources and activities that meet both the aims and constraints of the curriculum and students' own projects, knowledge and interests. It will also involve a partnership with companies to provide the technologies and services to support personal conversational learning.

The mix might include:

- shared online learning systems that provide the core course resources and teaching materials, developed as a partnership between staff, students, professional institutions and companies;
- problem-based learning through laboratory classes, field trips and study at home and in the workplace;
- support for personal learning, including helping students to create their own learning resources and also to form learning networks of people with similar needs and interests;
- collaborative project work;
- formative computer-mediated assessment.

There will still be an important role for didactic teaching and silent reading, but not necessarily in closed classrooms and libraries. There is certainly a need for schools, as communities of learners, but not necessarily confined to a single location.

3. Mobile Technology for Conversational Learning

The remainder of the paper describes the design of a personal mobile device for learning, a portable computer system that can be owned and carried by a learner and can support conversational learning in a variety of contexts. The general requirements for such devices are that they should be [18]:

- *highly portable*, so that they can be available wherever the user needs to learn;
- *individual*, adapting to the learner's abilities, knowledge and learning styles and designed to support personal learning, rather than general work or entertainment;
- *unobtrusive*, so that the learner can capture situations and retrieve knowledge without the technology obtruding on the situation;
- *available* anywhere, to enable communication with teachers, experts and peers;
- *adaptable* to the context of learning and the learner's evolving skills and knowledge;
- *persistent*, to manage learning throughout a long period of time, so that the learner's personal accumulation of resources and knowledge will be immediately accessible despite changes in technology;
- *useful*, suited to everyday needs for communication, reference, work and learning;
- *intuitive* to use by people with no previous experience of the technology.

These requirements set general boundaries on the system design (for example the learning resources and personal data should be separated from a particular hardware device, so that learners can gain access to their environment of learning materials, stored knowledge and captured experiences on different physical devices) but they are not constrained to a specific model or style of learning. For example, they may be designed for didactic teaching or skills training. The design described here is based on the conversational learning model, with explicit support for conversations between learners and teachers, between actions and reflections, and between learners and computer applications and resources. The technology, named HandLeR (Handheld Learning Resource), is intended as a prototype of a personal learning environment for a child aged 7-11. Just a personal organiser such as the Palm Pilot provides an integrated suite of software tools for organising daily life, so the aim of a HandLeR is provide the essential tools for daily learning, at school, in the home, or outdoors.

The prototype system was the result of a group design project by final year undergraduate MEng students, followed by an individual student project. The system was designed through a process of socio-cognitive engineering. This is an extension of user-centred computer system design that draws on theories of human cognition and learning, combined with task analyses and participatory design, to form a coherent specification of the software and hardware that is then implemented through an object-oriented approach to system design. For an explanation of the approach see [19]. Corlett [20] gives a description of how the object-oriented design method was applied to HandLeR.

Initially, three schools were visited and 219 children aged between 7 and 11 were asked to complete questionnaires designed to discover their learning habits and preferences. Small group interviews with children, teachers and parents were also held to discuss their learning needs and contexts. Among the findings were that the children preferred to work in groups, but to keep the results of their own work private. When they needed help, they preferred to ask a friend. More than 50% of the children stated that they did extra homework out of their own interest. The interviews enabled the team to construct a typical scenario of learning outside the classroom, based on a school field trip:

> A group of children aged 11 are taken on a school field trip to explore the canals of Birmingham. Each child is equipped with a personal HandLeR device that combines a pen tablet computer, digital camera, and wireless communications. The children are divided into two groups, each with a teacher. The children start by referring to their HandLeRs to discover the activity for the day. One group is set the task of finding how

> canal boats are used and powered in the present day, and the other group has to find similar information about canal boats of 150 years ago. Each child's device has been loaded at school, through a wireless LAN connection, with general background information on canal boats and waterways, including links to relevant websites.
>
> Having discovered their activity, the children browse for information that can guide them to answer the questions. They can move through a concept map on the screen following trails of related topics. Some of the trails lead to material on the HandLeR, others to link up to internet pages, and tapping on the screen downloads the page by a mobile phone connection.
>
> Then two groups set off round the canals to collect their evidence. The first group discovers that modern canal boats are powered by an engine, under the floor. The HandLeR has an integral digital still and video camera controlled from the screen. They capture a short movie of the engine being started and then sketch annotations on the initial movie image and add a text caption by means of handwriting recognition.
>
> The other children are exploring a different part of the canal to find the answers to their questions, about the canals of 150 years ago. They find notches in the span of a bridge and conclude that these are made by ropes from the horses that pulled the canal boats. They take a still image and add a short note. They then contact the first group, speaking to them through a direct mobile phone connection between the two devices. They exchange the annotated images via the data phone connection.
>
> They continue to find examples how canal boats were used in the past and present. As they build up the evidence, they share the results and begin to construct a shared topic map, which they will complete as a website of the investigation back in the classroom.

The scenario involves group experiential learning and peer teaching, guided by a teacher with pre-prepared activities and resources. The tools that are needed to support such a scenario can be divided into three sets, based on the conversational model: for *learning actions*, *learning descriptions*, and *learning conversations*. The basic tools for learning actions include a web browser for accessing learning resources and a notepad with handwriting recognition linked to an integral camera to capture, annotate and store objects that result form learning experiences (such as annotated images or movies, text notes, and web pages). Those for learning descriptions include a timeline to view the learning objects in the order they were created and a topic map for the learner to link the objects by conceptual association. If each learning object is stored internally as HTML, then as the child links them into a topic map this can also create an instantaneous website which can be shared with other learners or published on the worldwide web. The conversational tools enable the learner to hold a direct voice conversation or to share all or part of the topic map with another similar device.

4. Systems design

The prototype implementation was based on commercial hardware and software applications, with custom-designed software for the interface and user interaction. An important consideration in the design of technology for mobile conversational learning is how the system can present the learner with an interface and mode of interaction that is consistent, intuitive and enabling. The Windows desktop metaphor, of files and folders, is inappropriate because it is bound to traditional office work. Alternatives that were considered included a "virtual world" of locations and resources, but that would not map easily onto the real learning locations nor onto abstract entities such as a topic map. A blank notepad plus an array of icons representing individual tools such as pen and camera would allow the user to perform the basic functions but offers no unifying view of the learning and conversation.

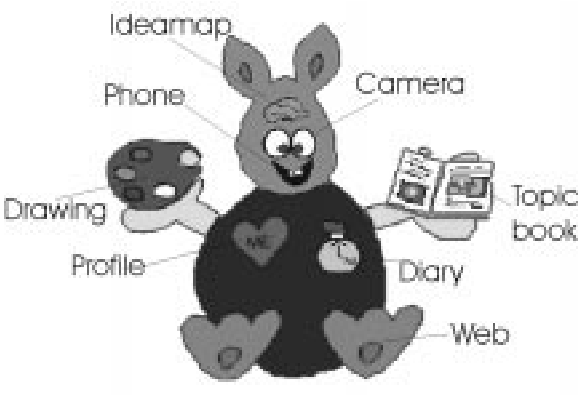

Figure 5. Rabbit avatar with annotations showing button actions

The decision was made to provide an avatar that would act as the user's *alter ego* in the system and also give a visually attractive and coherent method of interacting with the learning tools. In future versions of the system it could also reflect aspects of the user's personality or learning style. For conversation and knowledge sharing the user can select and interact with avatar images representing other learners and teachers. For the prototype system the avatar was shown as a cartoon rabbit (Figure 5). Parts of the body or objects held by the rabbit were associated with the system's tools. Tapping on the eyes activates the camera, the feet launch a web browser, and the book image activates the topic book where images, sketches and text can be assembled. In the prototype version these were standard software applications, so that, for example, the camera is controlled through the PictureWorks live software and the topic book is Microsoft FrontPage Express. Each of these tools has its own interface which created inconsistency. A more developed system would require a custom-designed tools with consistent appearance and interaction.

Figure 6. Main interface to the HandLeR

Figure 6 shows the main interface screen, with the rabbit avatar and a drawing tool for annotating an image captured by the camera. The buttons at the foot of the screen are to copy an image to the topic book, paint tool or topic map. The icon at the lower right allows the user to select another person's avatar to make a voice call or to share topics.

The learning descriptions are represented as a visual topic map (Figure 7) showing learning objects (notes, annotated images, web pages) connected by unlabelled links indicating their association. The interface was designed to be simple to browse through by single taps on the screen. At the right of the screen is a timeline showing the objects in the order that they were created. It is presented vertically rather than as a more conventional horizontal timeline to maximise the number of text labels that can be displayed on the screen. Dragging an item to the centre of the map attaches it to the central object. Tapping on an outside object brings it to the centre, and tapping on the central one shows its contents.

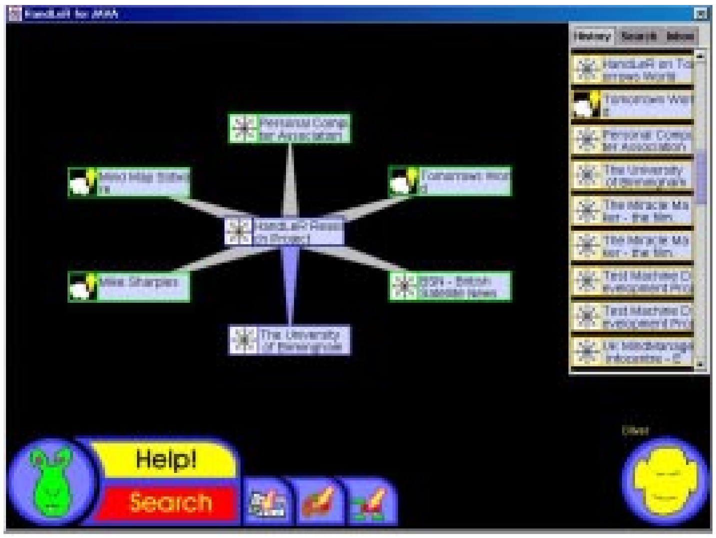

Figure 7. Topic map interface

Conversations are initiated by tapping on the icon at the bottom right of the HandLeR screen. This brings up a list contacts and selecting one shows that person's avatar on the right of the screen. A tap on the avatar's body shows a profile of the person and tapping on the mouth initiates a direct voice conversation. Dragging a learning object over the avatar sends it to that person's timeline.

The hardware for the prototype system consisted of:

- A Fujutsu Stylistic LT Pen Tablet computer containing an 8.4 inch 800 x 600 SVGA display with a touch sensitive screen and a 233MHz Intel Pentium processor running the Windows 98 operating system;
- A 3Com Home Connect camera in a custom-built bracket connected by a USB lead to the computer;
- A Lucent Technologies IEEE 802.11 standard PCMCIA card, providing wireless connection to a local area network with data rates of up to 11Mbs;

– A PCMCIA Nokia CardPhone, enabling direct voice communication from the computer to a mobile phone or to another computer, and data connection at 9.6Kbs.

Figure 8 shows the computer with camera and wireless LAN card. The Wireless LAN can either link the computer to a fixed network through a base station, or it can be configured in an ad hoc network that enables a group of people with handheld computers to exchange data at high speed up to a range of about 100 metres.

The system prototype implemented all the functions described above apart from the ability to share data between devices. For the field trials the Nokia CardPhone was installed, but not the wireless LAN card.

Figure 8. The hardware for the prototype HandLeR

5. Evaluation of the Prototype HandLeR

The prototype system was evaluated through a combination of methods, intended to provide both qualitative and quantitative information on its ease of use and usefulness for learning. The methods were: videotaped observations of three 11-year-old children using an early prototype; usability questionnaires with 29 children aged 10; and a day trial of the system, using an earlier hardware configuration based on a larger Fujitsu Stylistic 2300 tablet computer, with six children 11-year-old children and their teacher carrying out the scenario to explore canals in central Birmingham (this was videotaped for a BBC *Tomorrow's World* programme).

The children in the observation study successfully completed the tasks set for them such as creating a topic book, making a drawing, capturing an image and a movie, and setting up a phone call from the HandLeR to a mobile phone. Although they had suggestions to improve the interface, they found the layout and main functions easy to operate.

For the questionnaire study, the children were given printouts of the main HandLeR interface and asked to identify the functions associated with parts of the avatar. Each function was correctly identified by more than 50% of the children, apart from the feet (for internet access) and the watch (for a diary). In general, the children said that the design of the avatar was attractive and colourful but some of them commented that the cartoon rabbit was too "babyish". The children suggested a variety of alternatives, including animals, aliens, robots and cyborgs. We can conclude that if an avatar is used as the means of representing the user on the screen, then the user should be able to choose from a suite of images, designed in collaboration with children and appropriate for different ages. A more fundamental problem is that although the avatar metaphor could be extended to provide animated help and guidance, it could easily become contrived and overloaded with tools. Alternatives should be considered, such as the Pad interface [21] based on a camcorder metaphor of pan and zoom.

The day field trial of the system was successful, in that the children accomplished their tasks, despite having to perform for the BBC camera crew. They successfully navigated the topic map to find background information, made notes, captured still and moving images as evidence, and held voice conversations between the devices.

Since the BBC generally recorded rather than staged the events, it has been possible to carry out a limited study of the conversations and interactions from an analysis of the broadcast videotape. The children were split into to mixed-gender groups of three, each accompanied by a teacher. They began by referring to the HandLeR which presented their mission through an animated Powerpoint presentation. One group was set the task of discovering how canal boats are powered and used in the present day and the other group investigated the same for canal boats of the 1850s. Each group called up the topic map to browse and view an interlinked set of Powerpoint animations that presented facts about canal boats. For example, one showed a diagram of a boat that indicated the position of its engine. The “present day” group were allowed to search a canal boat to discover the engine under an inspection hatch. The other group went in search of evidence for earlier types of power and, finding a bridge with notches cut into the stonework by ropes, concluded that the boats were pulled by horses.

Each group captured images to illustrate their finds and made notes by pen on the screen, They found some difficulty with the handwriting recognition. The software, PenX V1.66 by Communication Intelligence Corporation, did not recognise cursive script, and the children found it impossible to balance the tablet on one hand and write with the other. By squatting or sitting down and resting the pad on their lap, they were able to make short notes.

The prototype software did not support sharing of data between the devices, but it did allow the groups to communicate by voice, using the microphone and speaker built into the computer. The conversation below is between the two groups about halfway into the activity.

> [Computer makes ringing sound]
>
> A: Hang on I’ve got a phone call. [Taps pen on “handset” icon] Hello.
>
> B: Hello Claire. How are you?
>
> A: I’m freezing.
>
> B: I’m freezing too. We’ve found the answer to the second question.
>
> A: What is it?
>
> B: Canal boats are used for trips and water-buses.
>
> A: Great, thanks.
>
> B: Bye
>
> A: Bye.

Despite being brief (no doubt due in part to it being videotaped and with a teacher watching) the conversation serves to coordinate the activities and share knowledge. It is prefaced by an exchange “I’m freezing…I’m freezing too” that establishes a shared context. It will be important to the design of conversational learning to provide different ways of creating a shared identity and context, such as informal conversation, exchanging images of the surroundings, and sharing notes and topic maps. A challenge will be to design tools and external representations that are appropriate to the learning activity, that can support conversation at the level of descriptions, and can bridge differences between the learners in location, prior knowledge, social setting and culture.

6. Discussion

As well as providing data on usability and usefulness of the prototype system, the studies raised some more fundamental issues of ownership and how such devices could fit into traditional school education. The children were universally excited by the possibility of owning a piece of "cool" technology that combines the functions of computer, mobile phone and digital camera. They also saw the value of possessing a device that could give them control over their learning. By contrast, the teachers who were interviewed saw the HandLeR as an opportunity to manage the children's learning away from the classroom and to build profiles of their learning activities and accomplishments.

A mobile learning device may become a zone of conflict between teachers and learners, with both trying to wrest control, not only of the physical device but also the opportunities it affords for managing and monitoring learning. This potential for confrontation needs to be recognised and addressed, before the children begin to arrive at school with conversational learning technology in their schoolbags. A first step is to separate out the hardware, software tools and online learning environment.

It makes economic sense for schools and colleges that where students own the appropriate hardware they be allowed to bring it into the classroom. The domestic market for such machines will be driven by their potential for multiplayer games and wireless data sharing and it is likely that within five years a similar percentage of children will own wireless-enabled handheld computers to those currently owning Nintendo Gameboy machines. The school might then loan additional devices. This raises further issues of equity of provision and the stigma attached to "technology-poor" students, but these are extensions of the problems already being raised by children using home computers for school projects and homework.

The first software applications for wireless machines are already appearing. These include general communications and mobile office tools, electronic books and networked computer games. The games and entertainment packages are likely to be the main areas of marketing to children and these will undoubtedly include "educational games" and "edutainment" software. There is an imperative to develop software tools and learning environments for mobile networked devices that are based on best practice in learning theory and educational design. It is to be hoped that companies will see commercial benefits from designing mobile learning systems, as a next generation of mobile applications beyond the current organiser and office tools. Educational institutions will then need to decide whether to allow learners to bring machines equipped with appropriate learning software, but also with games and communication tools, into the classroom.

If the student's personal learning resources and profile can be separated from the software tools, then another possibility is for future mobile devices to be designed so that they provide just the tools that are required or allowed in different contexts. The software tools would be loaded through a wireless network whenever the user moves between contexts. Thus, a child outside school might carry out project work using a handheld device equipped with games and entertainment as well as learning tools. When the child brings it into school the software is replaced with school-approved learning tools. The personal learning resources (such as web pages, topic map, timeline of learning activities, and personal profile) would remain on the machine as the child moves from one location to another.

7. Conclusion

The hardware, software and communications technology will soon be available and affordable to allow people to learn anytime anywhere and to share knowledge with colleagues and teachers. It offers the opportunity for children and adults to manage their own knowledge and learning across a lifetime of educational needs and experiences. It also poses deep challenges and disruptions to the traditional system of education. Mobile technology for conversational learning may follow other innovations ranging from the Logo “turtle” to electronic whiteboards and be appropriated within the educational system, or it may be fundamentally incompatible with the precepts of teacher-led instruction, the sealed classroom, a common curriculum, and individual assessment.

In January 2000 Hewlett Packard announced that they are designing what they term a ‘handheld learning appliance’ that combines a mobile phone and computer. In a speech to the Year 2000 Outlook Conference (http://www.hp.com/ghp/ceo/speeches/y2koutlook.html), Carly Fiorina the president of Hewlett Packard described it as follows:

> The appliance opens up a new set of possibilities for how educators can teach because they literally can have the world at their fingertips in the classroom. Getting bored in a French class? Connect with a class in France.

The technology for a child to connect with the world outside the classroom will soon be available, but we are only just beginning to understand the issues that such a disruptive device will raise.

Acknowledgements

I should like to give my thanks to the student team that produced the HandLeR prototype – Dan Corlett, Colin Murdoch, Oliver Westmancott, Jon Mangnall, Jan Nicholls, Gavin Phillips – and to the children and teachers who took part in the design and evaluation of HandLeR.

References

[1] OFSTED, "Primary education: a review of primary schools in England: 1994-98." London: The Stationery Office, 1999.

[2] OFSTED, "Secondary Education 1993-97. A Review of Secondary Schools in England." London: The Stationery Office, 1998.

[3] A. Kay and A. Goldberg, "Personal Dynamic Media," *IEEE Computer*, vol. 10, pp. 31-41, 1977.

[4] NOP, "Half of 7-16s have a mobile phone," NOP Research Group Ltd., 2001.

[5] NOP, "Kids Online: Numbers Double in Two Years," NOP Research Group Ltd, 2000.

[6] Cybiko Inc., "Cybiko, Inc. - Main Page," http://www.cybiko.com/, 2001.

[7] BBC, "Mobile phones: Child's play?," http://news.bbc.co.uk/hi/english/uk/newsid_591000/591791.stm, British Broadcasting Company Ltd., 2000.

[8] R. S. Prawat, " From Individual Differences to Learning Communities – our Changing Focus," in *Educational Leadership*, 1992, pp. 9 - 13.

[9] P. Jarvis, J. Holford, and C. Griffin, *The Theory and Practice of Learning*. London: Kogan Page, 1998.

[10] J. S. Brown, A. Collins, and P. Duguid, "Situated cognition and the culture of learning," *Educational Researcher*, pp. 32-42, 1989.

[11] A. G. S. Pask, *Conversation Theory: Applications in Education and Epistemology*. Amsterdam and New York: Elsevier, 1976.

[12] P. Freire, *Pedagogy of the Oppressed*. Harmondsworth: Penguin, 1972.

[13] T. Bentley, *Learning Beyond the Classroom: Education for a Changing World*. London: Routledge, 1998.

[14] G. Pask, "Minds and media in education and entertainment: some theoretical comments illustrated by the design and operation of a system for exteriorizing and manipulating individual theses," in *Progress in Cybernetics and Systems Research*, vol. IV, R. Trappl and G. Pask, Eds. Washington and London: Hemisphere Publishing Corporation, 1975, pp. 38-50.

[15] D. Laurillard, *Rethinking university teaching: A framework for the effective use of educational technology*. London: Routledge, 1993.

[16] A. Ravenscroft, "Designing argumentation for conceptual development," *Computers and Education*, vol. 34, pp. 241-255, 2000.

[17] Royal Academy of Engineering, "Engineering Higher Education," The Royal Academy of Engineering, London 1996.

[18] M. Sharples, "The Design of Personal Mobile Technologies for Lifelong Learning," *Computers and Education*, vol. 34, pp. 177-193, 2000.

[19] M. Sharples, N. Jeffery, J. B. H. du Boulay, D. Teather, B. Teather, and G. H. du Boulay, "Socio-cognitive engineering: a methodology for the design of human-centred technology," *European Journal of Operational Research*, In press, 2001.

[20] D. Corlett, "Innovating with OVID," in *Interactions*, vol. 7, 2000, pp. 19-26.

[21] K. Perlin and D. Fox, "Pad: An Alternative Approach to the Computer Interface," in *Proceedings of SIGGRAPH '93*, vol. 93. New York, NY, 1993, pp. 57-64.