Designing educational technologies with users

futurelab

a handbook from Futurelab_2004

Futurelab

By bringing together the creative, educational and technology communities, Futurelab is pioneering ways of using new technologies to enrich and transform the learning experience. Through our independent learning research, we identify gaps in the educational knowledge base or resource provision and develop ideas for compelling new learning resources.

A small, not-for-profit organisation, we act as a catalyst by creating productive partnerships between people with creative talent, technical know-how and educational expertise. Our partnerships are diverse: we work with individuals and large corporations, practicing teachers and government bodies, academics and venture capitalists.

Our activity comprises three interwoven strands: research, prototype development and communications. These core activities enable us to act as a think-tank that nurtures new ideas and gathers intelligence; as an incubator and tester of early-stage and untested concepts; and as a hub supporting the multi-directional flow of information and knowledge between practitioners, policy makers, creators and learners.

Futurelab
1 Canons Road
Harbourside
Bristol BS1 5UH
United Kingdom

tel +44 (0) 117 915 8200

info@futurelab.org.uk

www.futurelab.org.uk

futurelab

Designing educational technologies with users

A handbook from Futurelab

By Keri Facer and Ben Williamson

contents

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Our thanks of course to all the children, teachers and members of the public who have so enthusiastically participated with us in the development of these prototypes.

FOREWORD

One of Futurelab's central aims is to better understand the role that emerging digital technologies might play in education. To do this, we bring together the education community (teachers, researchers and children) with the technology and creative industries, to build and evaluate prototypes of the sorts of digital resources that might be seen in schools in the future. It is our findings from clusters of related prototypes, along with our intelligence about other relevant projects and research, that we publish in these handbooks.

The main aims of these handbooks are:

- to provide useful and jargon-free insights into policy directions, research and projects developing in a particular area of education and technology

- to summarise the findings from the prototypes and processes Futurelab has developed in this area

- to provide useful pointers concerning the design and use of digital resources in this area.

While these handbooks are not intended as definitive statements, we hope you will find them a useful guide and introduction to areas of interest and emerging development. If you have any comments to make, or suggestions of other projects or research we should be aware of, please do let us know.

Keri Facer
Learning Research Director
research@futurelab.org.uk

executive summary

In recent years there has been increasing concern about the apparent estrangement of developers of digital educational resources from those who are intended to use these resources - children, teachers or lecturers. The recent DfES E-Learning Strategy Consultation Document highlighted this as an area of concern, arguing that: 'The lack of a direct relationship between the users and the suppliers means that the products developed are less likely to meet learners' and teachers' real needs.'

Within the academic arena there are a number of different strategies for co-design with users; these include:

- Ethnography and user observation: users observed in existing activities and/or in natural settings using prototypes. Can take place at the outset, during, and on completion of a project.
- User testing: children or teachers observed trialling technologies and asked to provide feedback. Most commonly used in commercial settings at the end of development phases.
- Informant design: children or teachers seen as experts or 'native informants' informing designers of key issues related to their experience, helping to develop early design ideas and testing prototypes in development.
- Participant design & cooperative inquiry: Children or teachers working as a core part of a design team to identify ways of improving the environments in which they learn or work through the development of digital resources.

Futurelab's own approach to designing with users draws heavily on the informant design model and comprises expert informants, concept workshops, design testing, user observation and redesign of learning environments. Redesign of learning environments, in which we develop not only the digital resource but the pedagogic strategies and other resources required to create an effective learning environment, is an approach we believe has major benefits for realising the potential of digital technologies in education.

We have observed a number of significant benefits to the process of working with users:

- it offers first hand experience of the needs, interests and requirements of end-users
- it enables developers to 'free-up' their ideas and develop more innovative and creative resources
- it allows developers to be surprised by users and to avoid creating formulaic work
- it allows developers to avoid costly mistakes and to identify difficulties of design at an early stage
- it offers the opportunity to create resources that are embedded in teaching strategies and educational contexts, and which, consequently, actually achieve their educational aims.

There are a number of top level recommendations for working with users in the design process which include involving users at the earliest stage of concept development as co-creators, establishing a network of schools and advisors through contacts with LEAs and universities, developing a clear understanding of research techniques and establishing child protection policies. Advice on these can be found in the recommendations section of the handbook.

We recognise that for the small-scale multimedia development house, working to tight schedules and budgets, the incentive to find time to work with users in the development process can often seem slim. We hope that this handbook begins to offer a number of strategies for collaboration between developers and users of learning resources that might be adopted to fit the working practices of the real world.

Redesign of learning environments, in which we develop not only the digital resource but the pedagogic strategies and other resources required to create an effective learning environment, is an approach we believe has major benefits for realising the potential of digital technologies in education.

01_introduction

WHY THE FOCUS ON DESIGNING WITH USERS?

In recent years there has been increasing concern about the apparent estrangement of developers of digital educational resources from those who are intended to use these resources - children, teachers or lecturers. This handbook is intended to act as a 'matchmaker' between these communities, and a guide to the processes by which these communities might work together to create more effective and more relevant educational software.

The recent DfES E-Learning Strategy Consultation Document highlights the key areas of concern:

> The lack of a direct relationship between the users and the suppliers means that the products developed are less likely to meet learners' and teachers' real needs. We have not yet found the right mechanisms for the partnerships we need between developers and users. We have to create the conditions in which innovative ideas for e-learning pedagogy will flourish... Commercial suppliers usually employ teachers at some stage in the design process, but unless the partnership is close, and educational requirements lead the development, there is little chance of achieving either good pedagogy or profitable products. (E-Learning Strategy, DfES Consultation Document, Chapter 9)

How then, might suppliers, teachers and children develop these close working practices to achieve the dual aims of 'good pedagogy and profitable products'? What might these practices look like? How are they different from simply 'employing users at some stage in the design process'? This handbook aims to address these questions.

A brief history of development with users[1] →

In the late 1960s and early 1970s, Seymour Papert's research group at MIT had already begun to experiment with child participation in the design of learning resources. In the Scandinavian countries in the 1970s and 1980s, 'participant design' practices with adults were in evidence across a range of industries as worker involvement in the design of working practices, motivated by trades unions, was regarded as a catalyst for societal change. The 1980s also saw the growth of 'user-centred design' practices in commercial environments on both sides of the Atlantic. In the field of Human-Computer Interaction - a discipline which only came to fruition in the early 1980s - it has for some time been regarded as unusual for users to be excluded from design practices. Since the late 1990s, participative design with children has been most influenced by the work of the Human-Computer Interaction Lab at the University of Maryland.

Today, then, learner involvement in design is increasingly seen as a common sense approach to avoiding the pitfalls of designing resources that learners (and teachers) simply cannot stand, or cannot understand.[2]

Despite this involvement of children in design within academic research settings, user involvement in design schedules remains a persistently under-used strategy within the commercial context. For the small-scale multimedia development house, working to tight schedules and budgets, the incentive to find time to work with children in the development process can often seem slim. In the US, for instance, a recent Just Kid Inc report suggests that only 5% of organisations developing interactive media products for children involve their user group within a research and development process at all.

[1] This introduction is an abridged version of Ben Williamson's discussion document 'The participation of children in the design of new technology' available in full at: www.futurelab.org.uk/research/discuss/01discuss01.htm

[2] See Kafai in section 5

Approaches for involving users in the design process→

There are a range of different approaches to involving users in the design process. The approach most suitable to any given project will be dependent upon a number of factors including both 'philosophical' questions about the purposes of user involvement, and practical considerations of logistics, funding and so forth. The following table provides a brief summary of some of the approaches currently in use.

Approach	Users & roles	Aims	Common techniques
Ethnography and User observation	Users observed in existing activities and/or in natural settings using prototypes. Can take place at the outset, during, and on completion of a project.	To understand how users operate under existing conditions. To identify opportunities for new resource development. To understand how users use new resources in naturalistic settings.	Video, observation, field notes.
User testing	Children or teachers observed trialling technologies and asked to provide feedback. Most commonly used at the end of development phases.	To understand how users interact with new resources and to gain user insight on new resources.	'Talking aloud' during use, interviews, observation.
Informant design	Children or teachers seen as experts or 'native informants' informing designers of key issues related to their experience, helping to develop early design ideas and testing prototypes in development.	To generate new ideas about the needs and preferences of users, to draw on user expertise at specific phases of the design process.	User panels, user focus groups involving prototyping activities, user trials at specific stages of development.
Participant design and cooperative inquiry	Children or teachers working as a core part of a design team to identify ways of improving the environments in which they learn or work through the development of digital resources.	To enable democratic design and decision making in collaboration between users and developers.	Users seen as equal partners of the design and development team. Comprises four phases of gradual support for users to enable them to participate equally in the design process.

Ethnography and user observation →

These processes aim to understand potential end-users' habitual activities in their usual work or educational contexts. By observing people in their usual contexts, designers can identify problems and issues that might be overcome through the design of a new resource. In the education sector, this might involve observing classroom activities and identifying areas that teachers find hard to teach, or concepts that children find difficult to grasp, then creating a resource to respond to this need. Observation of users in natural settings can also be extended to prototype trials, where a new resource can be introduced to its intended end context and users' behaviour with that resource examined to identify further necessary design modifications.

User testing → User testing commonly refers to a process of trialling software with users to understand how they interact with and perceive the software. It is commonly employed to explore issues of usability by observing software in use, but users can also be asked to act as 'testers' and to provide feedback and comments on their experiences of use. This testing often takes place outside normal conditions, for example, in observation labs.

User testing can be employed as a critical component of an iterative process of product evaluation where the results of the user feedback are integrated into the redesign of the product or interface in question. More frequently it simply refers to the post-production de-bugging phase prevalent in commercial multimedia development. Critics of user testing suggest that user involvement is often employed, particularly in the commercial sector, too late in a development cycle to make a significant contribution to a product's development.

Both user testing and user observation are often co-opted into other processes, so that a more participative design process is likely to recruit members of a product's target group as both users being observed with technology at a very early stage, and as prototype testers during the product's development.

Informant designers → Informant design approaches employ users at regular stages throughout the development of new technology prototypes. Children and teachers are viewed as 'native informants' who are able to identify problems from within their educational experiences. The object of informant design is to discover something not previously known, rather than confirming what the design team thought it knew already. Rather than treating children and teachers as equal partners with the development team (as in participant design), informant design involves intended user groups at various stages, where and when their expertise can be maximised and where their knowledge is required.

Informant design starts with early discussions principally motivated by specific subject-related issues in which children and teachers are asked to identify problems and issues in their educational experiences. Based on these initial inputs, teams working with informant designers are able to transform the list of problems and issues into 'high level functionality requirements' for the design.[3] What follows is a series of low-tech prototyping using everyday materials such as plasticine, crayons and paper, in which children and teachers, working together with designers, come up with designs and ideas for motivating activities and interfaces. A high-tech prototype is devised, and then iteratively tested and retested with the group. Indeed, low-tech and high-tech prototypes are often worked on

[3] See Scaife et al in section 5

in parallel, informing one another throughout iteration, rather than the high-tech model following on from the low-tech version in a linear manner.

Participant design and cooperative inquiry →

Participant design (PD) treats users as partners in the design process who contribute equally throughout the product development cycle and work more as peers within the design team than as end-users. Primarily, PD has been mobilised successfully with groups of adults who are able to work together as peers naturally. Indeed, PD is rooted in the Scandinavian approach of the late 1970s and 1980s which was principally trades union-motivated and intended to enhance professional development for, among others, graphics workers and hospital workers. Many of its techniques have been adopted within cooperative inquiry approaches.

The cooperative inquiry methods developed by Allison Druin and her team at the University of Maryland have come to dominate HCI and interaction design conferences and publications in more recent years. This approach involves children as equal members within an inter-generational and multi-disciplinary design team, often comprising computer scientists, educators and artists. It involves working with groups of children on a regular basis - usually once or twice a week in out-of-school clubs over the course of at least one year. Some children return in later years as more experienced facilitators. During cooperative inquiry research 'children and adults write in journals, work on low-tech prototypes, brainstorm on paper or sticky notes, draw pictures, and think about how technology should change'.[4] As a result of this process, both children and adults involved in the process are seen to proceed through four distinct roles or stages:

1. As learners making sense of the process of invention.
2. As critics of what is good and bad in other inventions.
3. As inventors suggesting new ideas.
4. As technology design partners collaborating with adults and children in the invention process.

Cooperative inquiry has its own established techniques, drawing on a range of activities that can be performed with children. The first step is 'contextual inquiry', during which adult and child participants, working as a team of researchers, observe and analyse the users' environment for patterns of activity, communication, artifacts, and cultural relationships. Contextual inquiry allows the research group to identify the needs of the user group, and to proceed on to the next stage of participatory design. At this stage, the team develops low-tech prototypes of their ideas, including storyboards, plasticine models, drawings and sticky notes.

The final stage in this process of cooperative inquiry is technology immersion. At this stage, the children are introduced to an environment with technology resources that they might not normally have access to, so that they begin to understand and explore potentialities that would otherwise be inconceivable to them. This freedom to explore technology is also observed using similar techniques to contextual inquiry, and subsequent low-tech and gradually high-tech prototype iterations emerge.

[4] See Druin in section 5

01_introduction

Summary → What each of these different processes emphasises is that working with the intended users of a digital resource is about more than 'usability testing', more than insight into the appropriate location, colouring or layout of buttons at the end of a development cycle. Instead, these approaches offer the opportunity to draw upon the creativity, imagination and expertise of intended end-users to improve the quality, relevance and effectiveness of digital resources for education. Clearly there is no single 'right way' to work with users. The processes to be adopted are dependent upon the project, upon the intended audience, and upon the resources available to developers; but the underlying principle of respect for users, for their understanding and their expertise is one that can be embedded into all stages of a design cycle.

Learner involvement in design is increasingly seen as a common sense approach to avoiding the pitfalls of designing resources that learners (and teachers) simply cannot stand, or cannot understand. (Kafai)

02_designing with users

FUTURELAB'S APPROACHES TO DESIGNING WITH USERS

This section summarises the approaches to developing software with learners and teachers that Futurelab employs in its prototype development. The following table describes the main features of our current approach; we then offer a number of case study examples to provide an elaboration of these techniques.

What	Stage of project	Purpose	Involves
Expert advisors	At outset	Learn from previous work in the area. Ensure applicability of resource in educational contexts.	Identifying advisors from educational research and teaching to act as external expert critics of the project throughout its duration. Their role is to identify previous research and practice, to challenge the project against its educational objectives, and to provide an impartial perspective on the project.
Concept workshop with children and/or teachers	At outset	Check resonance of concept with target users. Elicit users' suggestions for development of the concept. Understand how users currently participate in similar activities.	A group of teachers or children will be asked to try out and comment on existing resources related to the concept (perhaps existing competing software, perhaps stimulus material related to the key ideas). They may be asked to create paper prototypes of an 'ideal' resource or of aspects of the interface or content.
Learning brief	Post-concept workshops	Create clear educational objectives for the project. Identify opportunities for working with users in development phases. Identify criteria against which each phase will be evaluated.	In-house production of written brief in collaboration between design team, research team and external advisors.
Design testing	Throughout development to completed prototype	Test key educational and design aspects of the prototype. Ensure early identification of problems and potential improvements.	Preliminary tests of paper-based prototypes or 2D versions or components of full versions with small samples of intended end-users. Half-day trials conducted outside context of use - either in Futurelab or in schools outside lesson time. Observation of use through video cameras, field notes; interviews with participants reflecting on use. We frequently work with children or teachers who were involved in initial concept workshops. **NB - we call this 'design testing' as it's the design rather than the users that is under scrutiny**
Trials	On completion of first prototype	Evaluation of the prototype against its stated educational objectives.	The prototype is trialled with at least 30 children in a 'simulated' environment. Usually occurring in a school setting and with the collaboration of a class teacher, these trials focus on intensive use of the prototype by small groups of children in the context of lesson plans designed with the class teacher.
Redesigning learning environments	Prior to and on completion of second phase prototype	Evaluation of the prototype against its stated aims. Establishment of necessary pedagogic context to ensure maximum benefits from use.	The project is redesigned and improved in the light of trial findings. Intensive collaboration with a teacher who is expert in the use of the new resource, to create a programme of work and a learning context (including other relevant resources and tools) that maximises the benefit of the prototype for educational purposes. This is then followed by intensive trials in which the teaching approach, ancillary resources and prototype are all subject to evaluation.

CASE STUDIES

↗ SkyBluePink concept workshop

↗ SkyBluePink concept workshop

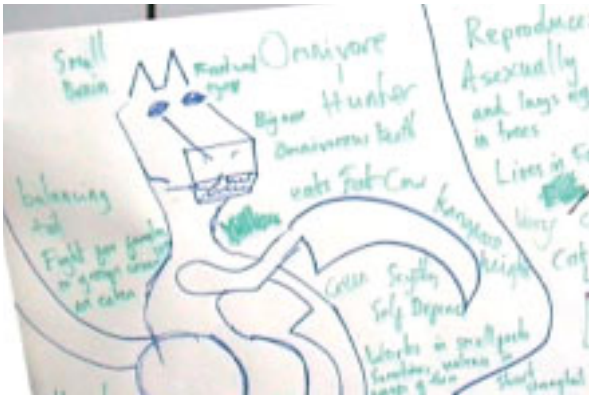
The SkyBluePink Interactive Box: concept workshop →
The SkyBluePink Interactive Box is intended to teach French to 4-5 year-olds through play. Children interact with a magic box and its characters (who appear on a computer screen) using cards embedded with radio-frequency ID tags to teach basic colours and shapes.

For the initial concept workshop we worked with a local primary school (in which French was already being taught), with the class teacher, a primary language expert from the local university and a class of 28 Year 1 children. The task set for children in this workshop was to play with coloured paper, shapes and pens to create images by cutting out and juxtaposing different shapes made from the paper. The task was chosen to replicate, in the physical world, the types of image creation, play and language work intended to be supported by the digital prototype. This task allowed us to explore how children employed French language in playful shape creation activities and how an expert teacher would scaffold that learning activity. The sessions were recorded using two digital video cameras and field notes taken by the researcher. Photographs were taken of the creations and the tapes generated during the session were transcribed and analysed.

Throughout the play activities, children told stories about the shapes they were creating and about their own lives. One boy, for example, created a 'footprint time machine':

'The engine is here, and there is another engine there that is solar powered and it shoots laser and this bit makes swimming pools[...] and this bit shoots ice cream out, and then it goes as an aerial and there is a TV inside and it can go to the stone age'.

The range of shapes created - from time-machines to people and landscapes - was a reflection of the open-ended nature of the task. Ideas and themes emerged and disappeared within an instant - a triangle became an ice cream making machine, and a circle a television set. The primary language teacher we worked with supported the children's French language learning by encouraging them to describe their work, encouraging recall and repetition of words within the playful context of shape creation and introducing new words throughout the process.

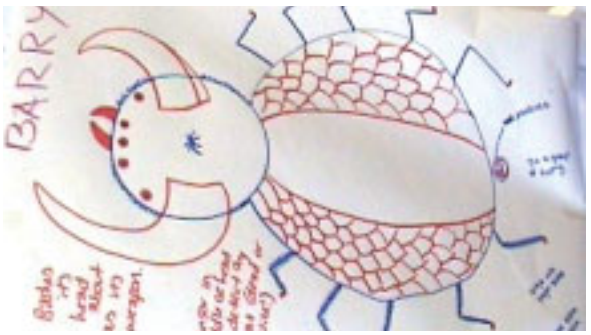


↗ Create-a-Creature concept workshops

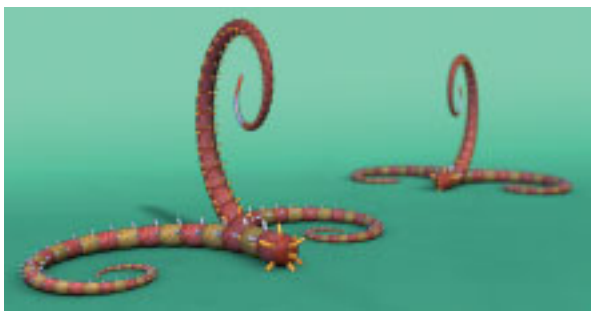
↗ Create-a-Creature concept workshops

Create-a-Creature: concept workshops → The aim of the Create-a-Creature project is to develop a persistent online world in which children are encouraged to think 'like scientists' through the creation of creatures for specific habitats and the observation of their behaviour and survival in different domains. One of its key objectives is to create an environment that is scientifically accurate at the same time as being an engaging play environment for children.

The initial concept workshop was intended to explore how children played with 'creature'-based games and to understand what features of creating and/or caring for digital creatures were engaging to the target age group. For this workshop, we invited two groups of children (in Years 5 and 6) to play creature-based computer games in their school for an hour. We brought into the school a number of different games: Zoo Tycoon (a Sims-type environment in which children create and manage a zoo); Impossible Creatures (where we focused on the creation of weird and wonderful creatures as a combination of two normal animals); Frankie's Animal Adventures (controlling an animal and doing puzzles as he wanders around the world); Disney's 3D animation software (which allows you to create animated environments for Mickey Mouse); and Startopia (a space station game). These games offered a wide range of different types of animal-based interactions - from creating creatures, to redesigning them, to caring for them. They also offered a wide range of different aesthetics and interfaces - ranging from complex statistical information in tabular form, to more intuitive click and drag image creation. The children were filmed



↗ Create-a-Creature



↗ Create-a-Creature

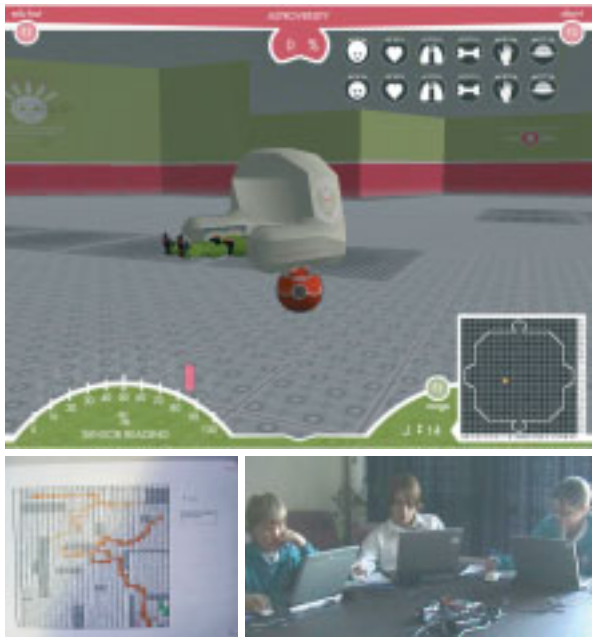
playing with these games over the course of two hours, were informally interviewed during play and formally debriefed after play to ascertain their responses to each resource.

Following this initial workshop, we also held a number of workshops with children in local schools, working with an animator from Aardman to explore the sorts of narratives and monsters children might be interested in creating in the online world.

Astroversity: iterative design testing → Astroversity is a three-player computer game designed to support scientific enquiry and collaboration skills. Three children play in the same room together on different computers to control probes that identify hazards in a disaster scenario. These players come together to plot routes through the environment in order to rescue survivors - survival vehicles are then directed down these routes and the players can see, in some detail, the different impact that hazards have had on the various organs of the survivors (or, in some cases, victims).

If this prototype was to be successful, the challenge needed to be sufficiently complex to stimulate collaborative activities, and sufficiently engaging to ensure children's motivation to continue playing.

The design process with users therefore focused specifically on the nature of the challenge of the game. So instead of moving directly from the concept to a full



↗ Astroversity

build of the 3D environment, we first created a paper puzzle that we trialled quickly with users. Based on this, a 2D game that modelled the features of the challenge was also tested quickly in schools. Visits of an afternoon to schools allowed enough time to identify features of the challenge that required revision, and aspects of the challenge that would be sufficient to stimulate collaborative activities. This early phase, which relied on paper-based note-taking on the part of the children, also encouraged us to continue with a mixed materials approach - building in paper-based notes as a key feature of the games playing strategy.

Welcome to the Neighbourhood: iterative design testing → Welcome to the Neighbourhood is an unusual project for Futurelab in that it is intended to support learning amongst the wider population, rather than just young people in schools. It is a dynamic signpost that can be controlled by the user to point to the locations of planets and other objects in space, linked to a digital interface that allows further exploration of these objects. In the long run, the resource is intended to sit in an outdoors location in city centres and public streets. The project is also unusual in that we have drawn on existing open-source software for which we have created a 'user-friendly' interface.

The iterative design process for this prototype involved a number of different stages to explore different features of the design with users. To begin with we identified the users we were most interested in reaching (low income groups with few formal qualifications) and contacted a local furniture workshop that employs many of these individuals and also sells furniture to low income and socially excluded households. Basing ourselves in the workshop for two days at a time for each trial, we invited individuals to participate in a number of different activities.

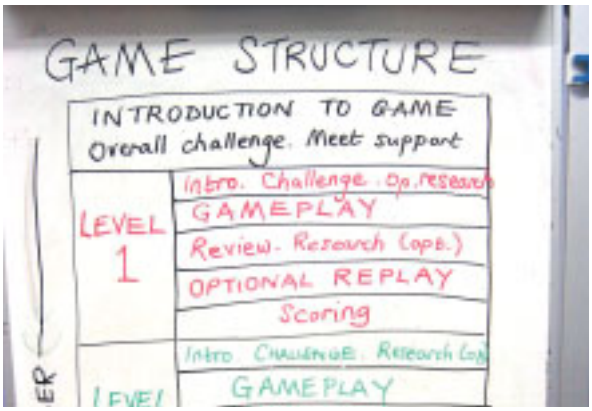
The first stage of work with this group involved a series of 'tests' involving paper cut-outs of planets, which we asked users to place in order in relation to the sun; we also asked them to conjecture about the relative sizes and distances of planets. This phase was designed to help us understand the baseline levels of understanding of the subject we were trying to cover with this prototype. Once this was understood, we then went away and designed a series of 'scripts' for the open source software we were using. These were designed specifically to show the relations, sizes and distances between the different planets in a way that was easy to understand for this user group. We then returned to the workshop to test our early scripts. In this phase we created a paper based interface and asked users to select particular options by pointing at the paper which would then direct one of the researchers who would 'drive' the software.

Welcome to the Neighbourhood: trials → This project is intended for use by the 'wider public' - a researcher's nightmare if ever there was one. How can we understand how effective a digital resource is 'for everybody'? To begin to address this we conducted trials over five days in four locations - a media arts centre, the furniture workshop where initial development work was conducted, a local primary school and a science centre. This offered us over 70 participants in the trials ranging from 4 to 70+ years old, with scientific expertise ranging from PhD level to no formal educational qualifications. All participants in the trials were volunteers, all were asked about their existing qualifications and interest and pre-existing understanding of the solar system. As the participants used the resource, they were asked to tell us when they were confused, when they were surprised, and when they were bored. This process of 'talking aloud' was also supported by the number of users who tried the resource out in pairs, offering conversations as data for analysis. These techniques allowed us to

↗ Welcome to the Neighbourhood trials

understand what was not clear in the design, what offered new information or new ways of thinking about the solar system, and which features acted as a disincentive to continue using the resource. The final debrief interview allowed the participants to more clearly reflect on the resource and provide suggestions for further developments and potential uses.

Virtual Puppeteers: trials → Virtual Puppeteers is a collaborative online puppet theatre enabling children to work together online to create characters, stages and narratives (for a full description see the Collaborative Creativity Handbook). For the final trials of this prototype we recruited a local primary school and a local primary teacher to work alongside us as co-researchers of the resource. This comprised developing a set of strategies for incorporating the resource into day to day teaching activities, and a set of research strategies for capturing how the resource was used. The research strategies comprised the class teacher working with a video camera to record children's interactions with the resource, keeping a log of his ongoing observations, and encouraging the children working with the resource to keep a journal of their use. At the same time, a Futurelab researcher visited the school to observe how the resource was being used in class, using a video camera and field notes to document the progress in using the resource.



↗ Savannah

↗ Savannah

Savannah: redesigning learning environments →

The Savannah prototype is a game that enables children to play at 'being lions' in a virtual savannah by navigating a real playing field. In the field children use GPS linked PDAs and headphones that show them the sights and sounds of the virtual savannah they are navigating as lions. The game comprises three levels in which children have to 1) claim their territory, 2) hunt as lions in the wet season, and 3) survive the competing demands of hunger and thirst in the dry season. Prior to and after playing as lions in the field, the children work in 'the den', which is a site indoors where they interact with teachers and resources to prepare for and reflect on their play.

We conducted two field trials of Savannah that in many ways resembled those described for other projects earlier. They were, however, notably different in the ways in which we worked with teachers to create an holistic learning environment rather than simply trialling the digital resource.

The first trials, conducted in November 2003, offered the opportunity to test the technology, and to explore whether it was possible to create a multiplayer GPS game that offered an engaging experience for children. The structure of these first trials involved a teacher delivering a traditional introduction to the subject area, and then, between games play, providing further information and encouraging the children to reflect on how well they had succeeded.

Following these trials we worked with the teacher involved in the project and with another expert technology teacher to develop a more effective strategy for creating a coherent experience. In the first trials, for example, we had noted that when playing out on the field as lions the children felt engaged and in control of the experience, yet when they returned to the den they became passive and disengaged with the information they were being given. As a result, for the second phase trials in April 2004 we developed a teaching approach that located the children firmly in the driving seat of the experience. We redesigned the game so that the challenges were sufficiently clear to enable the children to manage their own time and determine exactly how they should prepare for and develop their strategies for games play. We also worked to create a resource-rich environment for children that enabled them to research and prepare for games play through using pre-selected websites, books, models of animals, skulls and videos. The role of the teacher became as closely designed as the technology itself, as we experimented with different teaching strategies. Eventually, by the end of the trial process, we had refined a technique that maximised the benefit of the resources - namely, the clear definition of challenge and timescale combined with teachers acting as expert game players, who would be approached by the children for support when required, or who would at key points intervene to remind children of the resources and strategies available to play.

02_benefits

BENEFITS WE HAVE OBSERVED IN WORKING WITH USERS IN THE DESIGN PROCESS

This sort of work can sometimes feel as though it is a distraction from the important business of trying to make the prototype - when deadlines are tight and financial pressures are high, it is easy to think that time is better spent creating the final product and then seeing how it works.

These processes, however, have demonstrably aided our design process in many ways. For example, they:

- offer first hand experience of the needs, interests and requirements of end-users
- enable developers to 'free-up' their ideas and develop more innovative and creative resources
- allow developers to be surprised by users and to avoid creating formulaic work
- enable developers to avoid costly mistakes and to identify difficulties of design at an early stage
- ensure that the needs of users are kept uppermost in the minds of developers
- offer the opportunity to create resources that are embedded in teaching strategies and educational contexts, and which, consequently, actually achieve their educational aims.

There are two additional factors driving our commitment to designing with children and teachers. The first is that by involving children in the design process, children become aware that technologies don't simply 'appear', but that they are made by real people, making real decisions on a daily basis. This seems to us to be an important lesson for children to learn in 'the digital age'. The second is that through participation in the design process, teachers are able to become informed critics of the design of digital technologies, a process that in and of itself should serve to improve the quality of educational resources in the future.

Last, but not least, the process of working with children and teachers in the design process is constantly challenging and stimulating and gets developers out of the office and into the world for which their products are being made.

RELEVANT RELATED PROJECTS INVOLVING USERS IN THE DESIGN PROCESS

The following case studies give an insight into two further approaches for creating learning resources with young people and teachers.

Curriculum-focused design and WebKit → Jennifer A Rode, Mark Stringer, Eleanor Toye & Alan Blackwell, Computer Laboratory, University of Cambridge; Amanda Simpson, Institute of Education, University of Warwick

↗ WebKit tangibles prototypes

WebKit is a European Union funded collaborative project involving ten academic and commercial partners from across Europe. The aim of WebKit is to explore the application of tangible user interfaces to the internet, using radio frequency ID tags and other enhanced physical objects, particularly for school children. The Computer Laboratory at the University of Cambridge has been responsible for iterative design of these tangible interfaces, using 'learner-centred design' approaches.

The novelty of the Laboratory's approach is its insistence that 'learner-centred design' requires an understanding of the curriculum if it is to benefit the children and teachers involved in it. Indeed, initial work with teachers identified that exploratory approaches to learner-centred design outside of the classroom were not considered educationally valid because they fell outside of any curricular requirements.

Instead, the Laboratory's 'curriculum-focused design' methods have taken place within classroom and curricular contexts, since these are the contexts in

↗ WebKit prototype designs

which the intended new technology will be used. Thus, each session was designed specifically not to degrade the classroom experience or cover curriculum materials in an inferior way. The research trials specifically investigated how children can collaboratively gather, evaluate and arrange information for successful argumentation.

The research trial sessions were staged to start with 'no-tech' prototypes involving web page print-outs, proceeding onto 'low-tech' prototypes involving boxes and plasticine, and finally on to augmented 3D prototypes featuring RFID tags embedded in activity squares. At this stage children could add statements about information they had discovered on to the activity squares, which would communicate with a computer. The physical arrangement of statements on a tabletop or other work surface could then be mirrored on the computer. The children were thus able to 'construct' their arguments by directly manipulating the arrangement of statements.

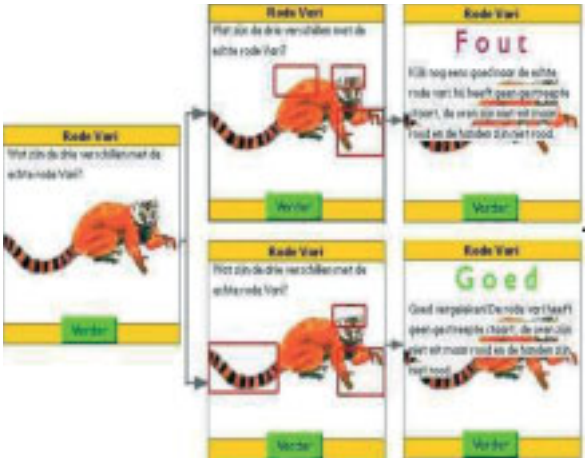
Although curriculum-focused design constrains the creative freedom of the development process, the Computer Laboratory reports that its iterative development process within a classroom context has significantly impacted on the environmental validity of the tangible user interfaces designed for WebKit. This should make them easier to introduce into schools, and more likely to be used by teachers who are always aware of their curricular obligations.

www.projectwebkit.com/index.php

www.cl.cam.ac.uk/Research/Rainbow/webkit.html

03_related projects

Examples of the Artis newspaper



Example of prototype 'Zoo Construction' game

KidReporter → Eindhoven University of Technology

KidReporter is a specific design method developed by researchers in the Netherlands to gather requirements for the design process of an educational game. The game was intended for use on a hand-held computer to help children learn more about animals while walking around the Artis Zoo in Amsterdam. In the study 63 children aged 9 to 10 years old participated in a range of activities that resulted in the creation of two newspapers about the zoo. The newspapers were then assimilated into the design requirements for the game.

KidReporter incorporates a variety of activities, each aimed at eliciting from students their interests in the zoo and their ideas for the game. By combining different activities, the project utilised the students' different preferences for modes of self-expression, including verbally and through image.

Some of the children took photographs during a visit to the zoo, and wrote about why each picture was taken and what was interesting or appealing about it. Other children developed lists of questions and interviewed each other about what interested them about the zoo; these interviews were tape recorded. A smaller number of children wrote more detailed articles about a single topic they found interesting, which provided detailed information on specific topics rather than global information about a variety of topics. The children also completed a questionnaire, where many of the questions were intended to determine what sorts of games both boys and girls enjoy.

At the end of the KidReporter research, the designer created a 'Zoo Construction' game that both the boys and girls had reported they would enjoy playing. The content of the children's newspapers was used to determine the content of the game, such as which animals and which topics to include in it.

One of the key strengths of KidReporter was that it encouraged children to think about using different media, including text, images, and speech, to record data, and through these media to demonstrate their preferences and interests. By analysing these together, the researchers reported that they were able to make stronger inferences about the children's opinions and ideas, and to construct a stronger and more appealing game.

www.ipo.tue.nl/homepages/mbekker/childproject

We have observed a number of significant benefits to the process of working with users:

- it offers first hand experience of the needs, interests and requirements of end-users
- it enables developers to 'free-up' their ideas and develop more innovative and creative resources
- it allows developers to be surprised by users and to avoid creating formulaic work
- it allows developers to avoid costly mistakes and to identify difficulties of design at an early stage
- it offers the opportunity to create resources that are embedded in teaching strategies and educational contexts, and which, consequently, actually achieve their educational aims.

04_recommendations

The following recommendations are predominantly practical, arising from Futurelab's experience of developing resources with users. Should you be interested in specific techniques and approaches, we would encourage you to read some of the articles and books included in section 6.

It's never too early to introduce end-users into the design process

- Consider throwing out all your existing project ideas and start observing what happens in schools and classrooms. You can design to meet needs and difficulties identified there.
- Consider using paper prototypes, models or role playing at the early stages to overcome the need for users to verbalise their ideas, particularly when working with younger children[3].
- Enable people to try out similar or new technologies first - good ideas don't emerge in a vacuum.

Be clear about what techniques you want to use and whether they'll really help you answer your questions

- Think beyond the interview to using observation, modelling, experimentation, design techniques - you'll get richer ideas and input.
- Remain aware of what you are trying to achieve - if not you may have a lovely conversation about what the children did last summer, but not a great idea about how your resource can help them learn science at Key Stage 2.
- Make notes and record observations instantly - otherwise you'll drown in your video data or just forget what you noticed

Be clear about roles in the design process

- Be clear about the roles you want users to play - do you want them to 'use' the technology, 'test' the technology or help 'design' the technology? If you don't, you'll get jumbled messages back.
- Be open with participants in the design process about any constraints or ideas you already have - if not, you'll only disappoint them when the prototype fails to live up to their ideas.
- Know what your own constraints are and understand the power relations in the process - are you really going to let teachers tell you what to do? If not, be clear about this.
- If you want users to work with you to co-design, you will need to develop strategies to put you all on a level playing field.

Set up a network of schools and advisors you know you can work with easily

- Each LEA has an ICT Advisor who should be able to advise on local schools who are interested in innovative work with new technologies. It is worth arranging a meeting with them to explain what you are attempting to do and how you would like to work and asking them to identify teachers and schools who may be sympathetic.
- At a national level, it is worth contacting NAACE and Becta for teachers who are actively involved in developing new approaches to teaching and learning with technology. In particular subject areas, the subject associations should be your first point of contact for expert advice. It isn't enough, evidently, just to find 'a local teacher', you need to find an excellent teacher who is reflective and able to think beyond the day to day demands of the curriculum.
- Local universities, particularly education departments with teacher training programmes, are an excellent resource for developers in that they often have expert teacher-educators who are not only expert in the subject area but familiar with the day to day realities

[3] 'Bodystorming' and 'Modelstorming' are two new approaches to designing with users that are worth exploring. See www.futurelab.org.uk/events/past/dd_pres/cmsb/cmsb01.htm for further info

of schools and classrooms. The MirandaNet and ITTE networks also comprise educational researchers who specialise in ICT and education. BERA (the British Educational Research Association) should be a first point of call for UK academics with experience in particular subject areas or with particular groups of young people.

- You need to be clear about exactly what sort of expert advice you need - is it someone technologically literate or someone with expert knowledge of a particular subject area? The two are not always the same person and can provide very different advice. If it is a subject expert, you may need to reassure them that they do not need to be technically brilliant - mentioning ICT can put a lot of people off.
- Make sure you meet an education researcher first before committing to working with them - some are brilliant at translating research into comprehensible language, others less so.

Think about all practicalities when setting up work with schools

- It is worth noting that the process of being involved in design and development is, for teachers, actively supported by the DfES E-Learning Strategy, and, for children, by the ICT curriculum.
- If you are trying to design for a particular audience, make sure you specify this when working with schools, otherwise they may see the research as an opportunity to reward their gifted and talented children, or to encourage their underperforming children. Which groups do you most want to work with? Within reason, attempt to work with the schools to achieve this.
- You will need to allow in your budget and planning for the costs of covering teacher absence if you are asking teachers to attend workshops or supervise trials or develop teaching activities. Teacher cover costs are usually around £150 per day.
- Always assume that at least two children in ten will either forget that they are supposed to be involved in a trial, forget to bring their permission slip, or would just rather not do it on the day. Have a back up plan and policy in place before that happens - will you accept 'replacements' from the school for example?

Do not overlook child protection issues

- Develop a clear child protection policy - state it to the schools you are working with and ensure you comply with their child protection policy.
- Informed written consent for children to participate in trials should always be sought from parents or legal guardians.
- Develop a clear data protection policy to explain how any video/audio recordings or photographs will be used and stored.
- Always anonymise all of your data - if possible, ask children to choose a pseudonym for themselves at the beginning of the research and use this throughout.
- Assume that schools will not allow you to work unsupervised with children. In which case, you may need to pay for another adult to be present, either a teacher or a classroom assistant.
- Consider getting Criminal Records Bureau clearance. Criminal Records Bureau Clearance can be obtained, but it is a difficult and often lengthy procedure. If you are likely to work with children on a regular basis within one local authority, it is worth talking to them about whether they can arrange clearance. Universities are also often registered to conduct clearance procedures. Unless you are a major organisation, it is unlikely to be worth your while arranging to be certified for conducting your own clearance procedures. An absolute minimum level of clearance can be achieved by asking schools to check you against List 99.

05_reading and resources

Policy

DfES. E-Learning Strategy Consultation Document: www.dfes.gov.uk/consultations2/16/docs/towards%20a%20unified%20e-learning%20strategy.doc
Identifies the importance of educational technology developers recruiting teachers and learners into the design phase of e-learning resources in order to design good pedagogy and profitable products.

User involvement and user-centred design

Bekker, M, Beusmans, J, Keyson, D & Lloyd, P (2003). KidReporter: a user requirements gathering technique for designing with children. Interacting with Computers, 15, 187-202
Summarises the methodological benefits and challenges of the KidReporter newspaper-making activity for gathering requirements for an educational game.

Bødker, S (1999). Scenarios in user-centred design - setting the stage for reflection and action. Proceedings of the 32nd Hawaii International Conference on Systems Science Online: www.computer.org/proceedings/hicss/0001/00013/00013053.PDF?SMSESSION=NO
Describes an approach to designing with users that incorporates real and fictional scenarios as inspiration for design work.

Gould, J D and Lewis, C (1985). Designing for usability: key principles and what designers think. Communications of the ACM, 28(3), 300-311. Reprinted in Baecker, RM, & Buxton, WAS (eds) (1987). Readings in Human-Computer Interaction: A Multidisciplinary Approach. San Mateo, CA: Morgan Kaufmann Publishers
Describes the emergence of 'user-centred design' approaches in Europe and the US in commercial environments during the early 1980s.

Knight, J & Jefsioutine, M (2002). Understanding the user: research methods to support the digital ,media designer. Research Issues in Art Design and Media, 3. Birmingham: Research Training Initiative Online: www.biad.uce.ac.uk/research/rti/riadm/issue3/abstract.htm
Describes how user-centred research methods can support decision-making in the design process, not by prescribing solutions, but by identifying the requirements, possibilities and constraints. Written particularly from an art, design and media perspective.

Kujala, S (2003). User involvement: a review of the benefits and challenges. Behaviour and Information Technology, 22(1), 1-16
Reviews a range of approaches to user involvement in design, with particular emphasis on participation in very early design work on prototypes. Positive and negative effects of different approaches are compared.

Markopoulos, P & Bekker, M (2003). On the assessment of usability testing methods for children. Interacting with Computers, 15, 227-243
Describes 'user-centred design' methodologies for children, intended to inform the differentiation of learning materials for different ability levels in new educational technology products.

Wiklund, M (1994). Usability in practice (editorial), How Companies Develop User-Friendly Products. London: Academic Press
Describes 'user testing' as a critical component of an iterative process of product evaluation, and where the results of the user feedback are recruited into the redesign of the product or interface in question.

Informant design

Scaife, M, Rogers, Y, Aldrich, ., and Davies, M (1997). Designing for or designing with? Informant design for interactive learning environments. Proceedings of ACM CHI 97 Conference on Human Factors in Computing Systems, 343-350 Online: www.acm.org/sigchi/chi97/proceedings/paper/ms.htm
Provides a detailed description of an 'informant design' methodology which treats teachers, pupils, researchers, and computer scientists as 'native informants' all contributing their particular expertise to iteratively develop new technology for learning.

COGS, University of Sussex. What is Informant Design? Online: www.cogs.susx.ac.uk/ECOi/inform_frame.htm
Excellent online resource from the COGS team at the University of Sussex, outlining the methodological and practical functions of informant design techniques.

Participation and democracy

Bjerknes, G, Ehn, P, and Kyng, M (1987). Computers and Democracy: a Scandinavian Challenge. Aldershot: Alebury
Case studies of the original 'participatory design' approaches employed across industry in the Scandinavian countries during the 1970s and 1980s.

Bjerkness, G and Bratteteig, T (1995). User participation and democracy: a siscussion of Scandinavian research on system development. Scandinavian Journal of Information Systems, 7(1), 73-98
Focuses primarily on democratic work places and democratic work processes, and on the potential for change at the wider society level.

Schuler, D and Namioka, A (1993). Participatory Design: Principles and Practices Hillsdale, NJ: Lawrence Earlbaum
Details the principles of 'participatory design' as developed in the Scandinavian countries and practised across a range of industries, including graphics and nursing, from the 1970s onwards.

Co-operative inquiry and children as co-designers

Druin, A (1999). Cooperative inquiry: developing new technologies for children with children. Proceedings of ACM CHI 99 Conference on Human Factors in Computing Systems, 223-230. Online: www.umiacs.umd.edu/~allisond/papers.html
Describes 'co-operative inquiry' methodologies working with groups of children employed as co-designers throughout the production cycle of new technology for learning. Treats children and adults alike as equal stakeholders in multidisciplinary and intergenerational design teams.

Druin, A (2002). The role of children in the design of new technology. Behaviour and Information Technology, 21(1), 1-25 Online: www.umiacs.umd.edu/~allisond/papers.html
A detailed review of the literature in designing ICT with children, and how these varied methodologies have contributed to the 'cooperative inquiry' approach exemplified by the University of Maryland HCI lab since the mid-1990s.

HCIL, University of Maryland. Kids Design the Future. Online: www.cs.umd.edu/hcil/kiddesign/design_process.shtml
Very useful online resource from the Human-Computer Interaction Lab at the University of Maryland, describing the elements that comprise cooperative design methodologies, with links to papers and projects.

05_reading and resources

Kafai, Y, Carter Ching, C & Marshall, S (1997). Children as designers of educational multimedia software. Computers and Education, 29(2/3), 117-126
An analysis of the learning benefits and problems for children who designed and programmed a multimedia learning environment for younger children as part of their science education.

Kafai, Y (2003). Children designing software for children: what can we learn? Small Users - Big Ideas: Proceedings of Interaction Design and Children 2003 conference. New York: ACM Press, 11-12
Provides a rationale for working with children in the design of new technology for learning, proposing that it is a common sense way of avoiding the pitfalls of designing products that children cannot use.

Learner-centred and curriculum-focused design

Rode, J, Stringer M, Toye E, Simpson A and Blackwell, A (2003). Curriculum-focused design. Small Users - Big Ideas: Proceedings of Interaction Design and Children 2003 conference. New York: ACM Press, 119-26
Online: www.cl.cam.ac.uk/users/jar46/final_IDC_paper.pdf
Details a learner-centred design methodology with particular emphasis on designing with children within the context of curricular activities and the environmental constraints of a working classroom.

Soloway, E, Jackson, S L, Klein, J, Quintana, C, Reed, J, Spitulnik, J, Stratford, S J, Studer, S, Jul, S, Eng, J & Scala, N (1996). Learning theory in practice: case studies of learner-centered design. Electronic Proceedings of CHI96. New York: ACM Press, 189-96
Online: www.acm.org/sigchi/chi96/proceedings/papers/Soloway/es_txt.htm
Suggests that user-centred design does not account for learners' growth, diversity and motivation, and outlines a learner-centred design approach, based on constructivism, engineered explicitly to support children's learning by designing.

Miscellaneous

Druin, A (ed) (1998). The Design of Children's Technology. San Francisco: Morgan Kaufmann Publishers

Good overview on methods for designing for and with children, providing discussion on how and why new technologies are being designed, the diversity of approaches that university researchers use in their research methodologies, and the range of technologies being created for children.

Papert, S (1980). Mindstorms: Children, Computers and Powerful Ideas. New York: Basic Books
Influential publication outlining the 'constructivist' approach to learning which sees educational technologies less as resources to be consumed, and more as resources to be constructed by children.

Doing educational research

The following titles provide an introduction to techniques for designing research interventions, for collecting and analysing data, and for linking practical research with educational theory. While not specifically related to the development of digital resources, they should provide a wider context for thinking about how to conduct effective educational research.

Cohen, L, Manion, L and Morrison, K (2000). Research Methods in Education. London: RoutledgeFalmer

Sapsford, R and Jupp, V (eds) (1996). Data Collection and Analysis. London, Thousand Oaks, New Delhi: Sage Publications Ltd

Brown, A and Dowling, P (1998). Doing Research/Reading Research: A Mode of Interrogation for Education, London & Bristol PA: Falmer Press

Guidelines for ethical research with children

British Educational Research Association - Ethical Guidelines for Research with Children
www.bera.ac.uk/guidelines.html

Contacts for relevant organisations

MirandaNet Fellowship
Any professional is welcome to join as a scholar if he or she is committed to the use of advanced technologies in the transformation of teaching and learning. Fellowships are awarded to scholars who add to the MirandaNet knowledge base through web publication of case studies and by presentations at conferences and seminars.
www.mirandanet.ac.uk

NAACE
NAACE is the professional association for those who are concerned with advancing education through the appropriate use of information and communications technology.
www.naace.org

Becta
(British Educational Communications and Technology Agency) Online communities where active and engaged teachers are involved in debating various uses of ICT.
www.ictadvice.org.uk/index.php?section=il&catcode=talk_index

ITTE
(Information Technology in Teacher Education) ITTE promotes the education and professional development of teachers in order to improve the quality of teaching and learning with ICT in all phases of education.
www.itte.org.uk

BERA
The British Educational Research Association was founded in 1974 and now has over 2,000 members and, through its associated societies, is in contact with at least 1,000 others engaging in educational research.
www.bera.ac.uk

Criminal Records Bureau
The role of the Criminal Records Bureau is to reduce the risk of abuse by ensuring that those who are unsuitable are not able to work with children and vulnerable adults.
www.crb.gov.uk

Futurelab
1 Canons Road
Harbourside
Bristol BS1 5UH
United Kingdom

tel +44 (0) 117 915 8200
www.futurelab.org.uk