From Snark to Park: Lessons learnt moving pervasive experiences from indoors to outdoors

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Abstract

Pervasive technologies are increasingly being developed and used outdoors in different and innovative ways. However, designing user experiences for outdoor environments presents many different and unforeseen challenges compared with indoor settings. We report on two different projects, one held indoors and one held outdoors, that were created to explore the use of various tangible technologies and pervasive environments for extending current forms of interaction, play and learning for children. In so doing the technologies had to be designed and adapted for the different settings. Using these projects as illustrations, this paper presents a contrasting analysis between indoor and outdoor pervasive environments, by identifying particular dimensions that change according to the location.

Keywords: Pervasive environment design, novel user experiences, play and learning, wireless networking, outdoor applications.

1 Introduction

> "*There is more information available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods*." (Weiser, 1991).

What about a walk in the woods where there is an overlay of wirelessly networked devices and technologies that can enhance the information available at your fingertips, where using computers and walking in the woods become enmeshed into an enjoyable experience? This was the experience for children, who took part in a school field trip with a difference - the Ambient Wood event (Price and Rogers 2003). The experience was designed to support scientific enquiry for children aged 11-12 years, learning about habitat distributions and interdependencies. Over a period of three days ten pairs of children engaged with an augmented woodland.

The contribution of this paper is to explore the issues that arise in designing an ambient computing event in this outdoor setting as compared to a similar event that was staged indoors. The indoor event was a digitally augmented adventure game for children between 7-9 years old, called the Hunting of the Snark (Price et al 2003), that also sought to integrate physical and digital spaces in novel ways.

While both of these events were similarly designed for children there were very different challenges to design for novel user experiences using pervasive and ambient technologies. Aspects that are often taken for granted indoors (e.g. continuous supply of electricity, network coverage) become real issues when outdoors [1, 2] and affect the kinds of technologies that can be appropriated and the user experiences that can be designed for.

Greenhalgh et al [3] discuss issues that determine the appropriateness of various interfaces with respect to practical constraints for supporting augmented reality environments. Here, we seek to complement this understanding by taking a broader approach that looks at the technological, logistical and design dimensions of pervasive environments for indoors and outdoors. These dimensions can be viewed as follows:

Technological Dimensions – These are concerned with the hardware and software components that when configured make up the pervasive environment. They include networking infrastructure, power, location detection infrastructure and performance of radio signals.

Logistical Dimensions – These are concerned with external aspects of the environment e.g. stability of the environment, availability of mounting points, surveying of activity space, setting up, testing, maintenance, safety, lighting and sound effects.

Design Dimensions – These are concerned with the needs of the user experience, including authenticity of experience, motivation of participation, place for reflection, recording user experience and environmental factors.

Before we describe the issues that arose in the design and execution of the two projects along these dimensions – the Hunting of the Snark (indoors) and Ambient Wood (outdoors) – we first position this work with respect to other ambient computing work and then provide an introductory overview of the two projects.

2 Moving to a ubiquitous computing vision

In another article titled “The world is not a desktop” Weiser (1993) sets out a goal of creating “a panoply of devices that could be ubiquitous in the home or office - hundreds per person, integrated with the everyday setting.” This ubiquitous computing vision, moving away from the desktop, has been the subject of much active research since. As indicated in the above statement, much of this research has focussed on home (Gaver et. al. 2003) or office environments (Arai et al. 1995; Black et. al 1995).

The Aware Home project at Georgia Tech (Kidd et al 1999), for example, is aimed at finding ubiquitous computing applications that will enable older adults to live independently in their homes for as long as possible. They have created an ‘aware home’ as a ‘living laboratory’ to explore these issues. The 'Ambiente - Workspaces of the Future' division at the Fraunhofer Institute IPSI is developing interaction environments - roomware® (Tandler et al 2002) - that include the integration of walls and furniture with information technology and smart artefacts to create interactive office settings. Both of these projects, as many similar ones, make use of purpose-built settings in which to research and develop these novel arrangements of technologies and devices with familiar physical spaces.

The projects we are comparing in this paper are also about moving beyond the desktop to explore “a panopoly of devices… integrated with the everyday setting” however we move away from the home and office as typical “everyday settings” for adults to think about children and how to provide novel playing and learning experiences for them.

A key objective within our work is to find ways of supporting playing and learning experiences that move beyond the ‘PC and educational software’ mindset. Instead of conceptualising educational technology in terms of designing software for children to sit down and interact with via a keyboard and a mouse at a screen, our focus is on determining how to augment everyday physical activities (e.g. walking, moving objects, manipulating things) through the provision of a diversity of digital representations, that are delivered to the children at relevant times, using a range of devices and pervasive technologies.

Hence, our emphasis is on finding ways of focussing the children’s attention on their everyday activities with the physical world, and where we see the role of technology to augment, extend and amplify those activities at hand. Our rationale for adopting this stance is, along with other seminal researchers in the field (e.g. Bruner 1973, Resnick et. al. 1996, 2000, Papert 1980), to bring ‘physicality’ and ‘embodiment’ into the learner’s experience so that children can be more actively involved in their learning. This approach contrasts sharply with the desktop model of computer-based learning where children react to and interact with software presented on a computer screen. The design goal is to provide opportunities for children to be more creative and imaginative, to think for themselves and to reflect more on what is happening around them and the consequences of their actions.

The Hunting of Snark project and the Ambient Wood project were both designed with these goals in mind.

2.1 The Hunting of the Snark: An indoor project

The Hunting of the Snark (Rogers et al 2002; Price et al 2003) project was an adventure game comprising of several different physical/digital couplings and explored different kinds and levels of physicality and embodiment. These were intended to provide novel and engaging forms of play for children aged between 7-9 years. Twelve children in friendship pairings, engaged in the experience, which took place indoors where a number of activity spaces in various rooms and demarcated lab spaces were created.

The goal of the game was to discover as much as possible about an elusive virtual creature, called the Snark, which is hidden in virtual space and appears digitally in a variety of physical places (e.g. the water, land, air). Pairs of children have to interact with the virtual Snark by feeding it in a well where it is swimming, by walking around in a cave where it is sleeping, and by flying with it in the air.

Figure 1: Feeding the Snark in the well

Various sensor-based devices were constructed and disguised to enable these to happen. These were a snooping room, where children had to find virtual clues using a snooper device, that enabled them to enter other activity spaces; a virtual well where the children could use RF-tagged physical food tokens to feed and elicit a response from the Snark; a cave in which the Snark responded to children’s movements by sonification triggered by location-based sensor information; and a flying experience where the children wore cyber jackets to interact with the Snark. Within these spaces, a range of pervasive technologies were used to support the user experiences; PDAs, cyber jackets, and tangibles (RF-tagged objects).

2.2 Ambient Wood: An outdoor project in the park

Building on the experiences gained from the Hunting of the Snark project, we decided to develop a learning event – the Ambient Wood project - that would move 'the learning experience' away from indoor settings or the classroom out to a wooded habitat that was augmented with wireless network and various devices and sensor-based technologies (Price et al 2003). Besides being much more technically challenging, a primary motivation was to explore ways of augmenting the physical world to promote thinking and reflective skills in the context of learning about scientific enquiry – a field trip with a difference.

To this end, a playful learning experience was developed, providing children with a variety of ways of exploring and understanding a wooded habitat that was augmented with various digital abstractions. Some were triggered by the children's exploratory movements, others they collected themselves, while still others were tracked over time.

The children explored the physical wood by looking, listening and touching what was around. They also used a variety of customised probing and magnifying devices that allowed them to do and see things they could not do otherwise (see Figure 2). These included making the invisible visible, making the inaudible audible, bringing the far to the near and seeing the past and the future in the present. The provision of these kinds of digital visualisations and sounds, closely coupled with the physical entities they were referring to, gave the children an alternative means by which to abstract and integrate their knowledge about the various physical processes taking place in the wooded habitats.


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Figure 2: Children using devices in the wood

A variety of devices and multi-modal displays were used to trigger, track and present the 'added' digital information. For example, while exploring the wood, pairs of children collected data relating to different habitats using probes that wirelessly transmitted moisture or light readings, along with the position information, to a software state engine.

Figure 3: Periscope with screen and RF-tagged plates for triggering information displays

As another example, there was a 'periscope' (see Figure 3) that provided a visual/audio display device that allowed the children to find out information not normally or readily available (Wilde et al, 2003). In the wood, children could use the periscope to find out about seasonal changes, or organisms or processes not normally or readily visible to the naked eye. The periscope also has a RFID tag reader where children can place 'tokens' of, for example, an organism which triggers more information about the organism to be presented on the screen of the periscope.

Various other devices were also used to reveal information about the wood to the children intended to provide an enhanced appreciation of the habitats they visited. At the end of the field trip, a central 'den' area was used to allow the children to reflect on their findings and build hypotheses about what would happen if certain changes occurred in the habitats. Studies show this to be a highly engaging novel experience for learners. They particularly found the probing activity (both collecting and subsequent viewing of the data) to be a thoroughly engrossing experience. They also demonstrated enthusiasm using the periscope device, to find out more about the creatures or plants they had discovered, themselves, in the habitat. In addition, the studies suggest this kind of experience effectively supports collaborative learning (see Price et al 2003), as well as providing preliminary guidelines for designing different ways of delivering digital information for learning.

3 Dimensions to consider in indoor/outdoor design

Both the Hunting of the Snark and the Ambient Wood projects shared many similarities. Both were designed to bring physicality and embodiment into playful/learning experiences for children where children walked, talked, touched etc. Both used a collection of novel devices and technologies and spatial arrangements to stimulate exploration and discovery. And both were run as 'experience events' in which children actively participated. However, the effort to design, construct and deploy the technologies for these events was very different, largely due to the differences in setting. The Hunting of the Snark (hereafter also called Snark for brevity) was run as an indoor event in a university lab environment; the Ambient Wood was an outdoor event in a country woodland. The issues we had to deal with and the lessons we learnt can be explored along three dimensions: technological, logistical and design.

3.1 Technological dimensions

Networking infrastructure – Snark was run in an indoor lab environment where hardware networking infrastructures are commonplace. With plenty of available access points, connectivity for computers was easy. The availability of networking resources becomes an issue as soon as you take technology outside of hard-networked spaces. Urban built-up areas have recently seen the growth in availability of wireless networks supporting the 802.11b standard but these still are in their infancy and coverage is limited. When considering the countryside beyond the urban environment, such facilities are even more scarce and there will almost certainly be a need to build some form of LAN.

With the Ambient Wood project, there came a necessity to provide a communication infrastructure between the devices used by the children and the state engine which orchestrated the control logic of the experience. In choosing a solution for this we considered a number of approaches using differing arrangements of technology, the core requirement being the need for a wireless network. Since there were only two realistic contenders for this (Bluetooth or IEEE802.11), it was quite straightforward to make a selection between these technologies based on comparison of the communication ranges. During trials of the two technologies we experienced Bluetooth line of sight, peer to peer connectivity of approximately 30 meters, whereas with 802.11 we achieved up to 100 meters.

Figure 4: Booster antenna for 802.11b network

Unfortunately, trees tend to be fairly effective at blocking the radio frequencies currently employed by IEEE 802.11b wireless networks and, despite the aid of a reasonably powerful antenna, seen in Figure 1, we were unable to cover the entire area with a single access point. Instead, we chose to use three access points, which were combined into a signal ethernet segment using the wireless distribution system (WDS) protocol and IEEE 802.1d ethernet bridging (see Figures 4 &5).

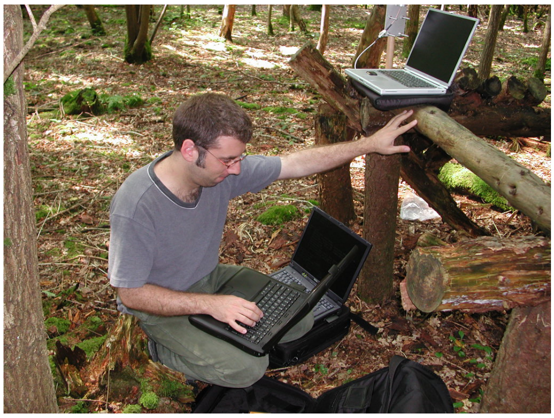

Figure 5: Network access points being tested

To forecast the range of the network coverage with the use of isotropic antennas, circles can be drawn about the access points. This becomes the theoretical area of coverage, but it pays little account of the actual environmental features present outdoors. To maximise coverage outside, the projected baselines between access points should be as clear as possible from obstruction, providing clear "line of sight" communication.

At the time of our study, WDS was only supported in a few, very expensive commercial access points and by a special Linux driver for Prism2-based cards. We chose to go with the latter option as being both cheaper and more flexible -- we ended up using three access point laptops to play sounds and to run the Elvin server -- and created a tiny Linux distribution with all of the necessary software and drivers which could be used in any Intel laptop with a PCMCIA slot and which could boot off of a floppy or a CD.

Power – One of the most significant factors in choosing technology is the power resource available at sites where the projects are run. For the Snark project, the ubiquitous availability of mains power is taken for granted. For the Ambient Wood project, where large amounts of technology needed to be powered for up to four or five hours of continuous runtime, power became an issue.

A petrol powered electricity generator was considered as inappropriate both because of noise as well as the cable routing issues (our devices were spread throughout the wood, and the line supply of power to each would get very messy). Instead we opted to power everything by battery and actively discouraged the use of power hungry devices in the design phase. Most of the technology utilised transformed 12 or 24 volts dc, so building battery packs for them with sealed lead acid batteries was quite straightforward.

The supply of uninterrupted power can be critical, so applying safety margins becomes prudent practice. When choosing an appropriate power rating for the made-up battery packs, as seen in Figure 6, a multiplier of one and a half is wise. The power requirements for notebook computers will vary considerably dependent on the need to power peripheral devices, either integrated into the computer such as the hard drives and LCD screens, or those interfaced to the computer e.g. PCMCIA wireless network cards.

Figure 6: Battery pack supplying the computer

A further consideration was the amount of activity that the software could demand of peripherals through the frequency of calls to devices. We noted a significant drop in notebook battery life when running some of our Director™ movies which had a high instance of hard drive access. However we were able to extend the life of the power packs supplying radio frequency equipment by reducing the frequency of calls from 4Hz to 2Hz and by turning off the LCD screen of the laptop when the display was not needed.

Location detection infrastructure – Being able to fix the position of people and objects is a common requirement for pervasive environments and was needed in both Snark and Ambient Wood. The availability of satellite based tracking systems that provide positional information indoors does not currently exist, and so there is a need to use alternative technology to provide a solution in the Snark project. One approach we chose to use in Snark was ultrasonics (Randell and Muller 2001). This could provide positional information to an accuracy of about 20cm (though it can be better and worse).

However to transplant this ultrasonic positioning technology outdoors proves difficult. Firstly it suffers from a lack of reflected signals. Secondly it also suffers from fixing and calibration problems. The acoustic transponders need to be positioned securely and experience no movement when operational. It is highly unlikely that we would be able to find appropriate fixing points in a wood that kept the transponders in place whilst allowing access for maintenance. An alternative position-fixing solution was required for the outdoors.

Within the Ambient Wood project, position was provided by a number of methods. GPS, Radio Pingers and Dead Reckoning were all used to build a model of the children's position. This position information was used to activate responses on the PDA's as well as to drive wireless speakers hidden in the wood.

Of the systems deployed in the wood, we saw the most positional stability from the Radio Pingers, these having a range of between two to twenty meters (depending on a number of factors) with repeatability of under a metre. The GPS information in the wood had a tendency to slowly drift up to seven meters. This made it inappropriate to be used for the triggering of events that were meant to be closely linked with the children's position. Data from the GPS was still useful though in providing qualitative information about the route used through the woods by the children.

Performance of radio signals – The performance of radio signals will vary depending on the conditions present in both indoor and outdoor settings. Indoors, there is a potential for electromagnetic interference (EMI) from a variety of sources from power lines and motors, through to high speed data lines and wireless devices. Although there are clearly defined regulations to prevent electromagnetic emissions from causing contamination, as well as a responsibility on device manufacturers to show an amount of electromagnetic immunity, laboratory environments such as ours used for Snark often display a high quantity of noise.

We did experience EMI interference in Snark where we had problems with the biggles cyber-jacket (a wearble computing jacket using 802.11b) because of cross-talk interference. This is not surprising since laboratories often concern themselves with the design and prototyping of devices where EMI considerations are implemented at the end of the design. In future indoor events, we would make sure that we set up different channels and that access points were uniquely identified so that they could be clearly separated.

When taking radio-based technology outdoors, as for Ambient Wood, the properties of the trees and weather become more important. Broad leaf trees will block incoming GPS signals whilst high levels of humidity will attenuate radio waves.

Although there are different forces at work affecting radio signals indoors and outdoors, we adopted what is considered "good practice" and tuned the antennas in situ whether indoors or outdoors. The timing of any interference that is experienced is worth noting since in some cases it might be cyclic and thereby give a clue to the cause.

3.2 Logistical Dimensions

Stability of the environment – An indoors environment, such as that used in Snark, is relatively fixed in its nature. Doors and walls typically stay where they are and changes in layout are relatively easy to restructure. This environmental stability and predictability makes it relatively easy to design a pervasive environment to be used over repeated trials and locations.

When moving outdoors we enter into a more dynamic setting where the surroundings can change from day to day, month to month and between the seasons. Paths covered with a carpet of Bluebells in bloom one day will disappear as the season changes. Similarly, what is a marshy swamp in the winter can become a grassy clearing in the summer.

These changes can have a significant impact on both the working of technology as well as the continuity of the supporting scenario. Of course such changes also offer the opportunity to use technology to fix the time frame when certain interesting events happen. Within the Ambient Wood project, our trial run took place in the spring and the real run in the summer. Because the seasons were quite distinct it required us to design different scenarios for the activities, even though one was a trail run of the other.

Availability of mounting points – Buildings offer a structural framework that is often taken for granted when needing to fix technology to a space. Walls and ceilings are characteristically strong surfaces that not only offer good fixing points but useful planer references for positioning technologies. The Hunting of the Snark project exploited this feature by placing the ultrasonic transducers needed for the snooping activity on the ceiling. These were parallel to the users of the technology thereby providing the Cartesian coordinate frame X/Y.

In comparison, this structure and stability are no longer evident when placing technology outdoors in a wood. The ground might be soft one day hard the next and probably uneven and the trees (which offer the only natural fixing points) can move. Much improvisation and serendipity are needed to find places to put the technology; the tree branches in Figure 7 were seen as adequate 'angle brackets' for holding a network access point. Where a fixing to the ground is required, a base plate secured with tent pegs can offer a stable platform. This method was used, for example, to mount the periscope (Figure 3).

Figure 7: Network access point

Surveying of activity space – Because the geographical space itself is such an important part of events such as Snark and Ambient Wood (people move around a space and interact with features of the space), there is a need to have a survey of the area. This is relatively straightforward for indoor settings as blue prints for buildings are kept as a matter of record. Documents that hold this detail do not exist however for outdoors. In the UK, land deeds will have general areas mapped, but to obtain particular detail to the site i.e. paths, small buildings, specific trees and such, it becomes necessary to conduct the survey yourselves.

With the Ambient Wood project, we identified and referenced the major paths by superimposing GPS data, gained from a person walking through the wood, over a multi-map projection of the area, the outcome of which is shown in Figure 8.

Figure 8: GPS generated track overlaid onto aerial map

Setting up, testing and maintenance - The installation of pervasive environments requires significant effort. Each piece of technology needs to be tested in isolation as well as an integrated part of the whole. Fault finding can take considerable time with bugs being chased from one bit of technology to another, or hardware failures being accommodated by lenient software only to reappear later in the project. In the Snark project, the set-up and testing only had to be done once. In an outdoor environment, this work is compounded because we need to disassemble the technology on a daily basis to prevent moisture deposits on electrical boards as well as concerns over security. This building and rebuilding of the pervasive environment makes reliability of the setup an issue that needs careful management.

With the Ambient Wood project, this problem was tackled by testing sections of the technology on site at separate times. In particular, as the design of the 802.11 network matured, we ran performance tests a number of times on site, the wireless network being seen as a critical backbone component of the installation without which the whole experience would have fallen apart.

Weather – The Hunting of the Snark project did not suffer from problems associated with the weather since it was run indoors, where the environment was controlled.

Putting technology outdoors in temperate latitudes runs the very real risk of being rained on. Most technology can be designed (at a price) to be placed outdoors to varying degrees of resilience to the elements, following NEMA or IP protocols. We, however, configured devices that had little resistance against the weather and consequently we always needed to keep a keen eye on the forecast. To offer a small amount of protection from the rain for the technology used in the Ambient Wood project, we placed polythene bags around the equipment, which kept it splash-proof (see Figures 9 and 10).

Our only other contingency plan for the Ambient Wood project being "rained off" was to suspend the experience to another date. One of our trials runs became affectionately known as the 'wet run' as opposed to a 'dry run' because of the precipitation that accompanied the event.

Figure 9: Pingers protected in a plastic cup

Figure 10: Technology draped with polythene sheets

Safety – Indoor spaces are characteristically easier to control than those outdoors, and as a result more straightforward to make safe. In outdoor spaces there can be many dangers (pond, rabbit holes, barbed wire), many of which cannot be removed. Before inviting students to experience their field trip with a difference, we had to conform to a legal requirement to carry out a risk assessment, identifying the hazards present. Following this, such hazards needed to be removed or minimised where it was not possible to remove them altogether. In Ambient Wood, for example, we couldn't fill in all the rabbit holes so had to choose a path with the fewest rabbit holes to take the children along.

Lighting – The lighting conditions encountered indoors are predominately fixed and controllable. Potentially degenerative effects on the Snark displays were therefore easily countered by modifying either the light source or the display angle. In taking display devices outdoors, the effects of the lighting conditions became more significant. Each display had to be assessed for the possible range of light levels that might occur with that device, from bright sunlight through to overcast conditions in a thicket. Where there was a need to have a clear sharp image, we used hoods to minimise contamination by spurious light. We also needed to take into account the diurnal change in light level and direction.

Sound effects – Both projects exploited the use of sound. In Snark, we needed to be aware of the ways in which the acoustic properties of the lab space varied. In the Ambient Wood project, the experience was enhanced for the students by the atmospheric qualities and ambient sounds inherent outdoors. It was more difficult to introduce sounds into the space because the spatial quality of sound changes when taken outdoors. The lack of planar surfaces to reflect off of provides a more distributed feel to the sound.

We also found that students sometimes found it difficult to distinguish generated sounds that were triggered by some action of theirs from the inherent sounds in the wood. This was particularly the case for a distinctive bird sound that we had chosen to be triggered on the basis of the children's location – when we ran the event, there was an unusual number of these birds actually in the woods and so no one knew whether the bird was really there or not! The best sound we chose was that of a badger because these did not blend into the ambient sounds of the wood at that time in the same way and so were more easily distinguishable.

We also investigated the use of surround sound for both the Hunting of the Snark and the Ambient Wood projects to create a three dimensional sonification experience, but found the problems of "sweet spots" dependent on head-orientation too limiting for "mobile" interactions. Spatial representation of sound was instead created through stereo and quadraphonic speaker systems.

With speakers placed outdoors, we were concerned with the effects of wind carrying sounds from one area to another. This worry was found to be groundless since, surprisingly, the thicket did a very efficient job of insulating sounds.

3.3 Design dimensions

Authenticity of user experience – The user experience will naturally differ in an indoor setting from an outdoor setting, and the design of the activities, tasks and devices will differ accordingly, making the experience 'authentic' or appropriate for the particular environment. Each space (indoor or outdoor) offers different constraints and lends itself better to different kinds of activities.

For example, the Hunting of the Snark project consisted of several tasks and activities that were designed for confined spaces, such as the well and the cave. Here, children needed only a small space in which to achieve their goals. However, the outdoor space available in the Ambient Wood project inherently enabled children to participate in significantly different activities, not confined by space (e.g. exploring). On the other hand, an indoor area may lend itself better to the construction and creation of a wider variety of different settings (e.g. dark cave, well environment and dark room for flying), whereas in outdoor settings it is harder to disguise and create ‘alternative’ environments and the environment itself can be co-opted as an integral part of the experience.

In other words, outdoor experiences have to be adapted to the environment, whereas with indoor experiences the environment can be more easily adapted to different atmospheres and ambiences.

Motivation of participation – Children are particularly motivated by novel experiences, but the motivation may be different or even enhanced when outdoors. Children are highly motivated when they are taken out of the classroom, as this immediately offers a significantly different kind of activity. Being outdoors may provide additional motivating factors. For example children have more space and therefore freedom to move around, enabling different kinds of activities than indoors, such as exploring, using walkie talkies at distance. This, in itself, potentially offers a more open-ended, self-directed kind of interaction. Activities designed for an indoor space, such as used with the Hunting of the Snark project resulted in more linear close ended kind of interaction.

Place for reflection – An important part of the learning and playing experience is to facilitate and enable children to reflect on their activities and interactions. Indoors, this kind of ‘reflection’ place is readily available in the form of an area within a room or a separate room where a computer can easily be provided to support reflection if required. However, in the outdoor wood setting, we needed to create a special place that will not only support the use of computers, but will also engender an atmosphere to facilitate reflection. For the Ambient Wood project this was achieved by creating a ‘den’ in a small marquee space, where children could sit or stand around tables with an interactive tagged board and computer displays where they could manipulate and discuss information they found in the wood.

Recording of user experience – For research purposes, the collection of good quality audio and video data is often a prerequisite for the running of activities in pervasive environments where users are mobile. The setting up of equipment to collect this data is more straightforward when deployed indoors. The activities are typically within a confined area, with good fixing points, where the placement of recording devices can be made unobtrusive.

Recording in pervasive outdoor environments can take advantage of the lack of physical boundaries. However placement of technology around a geographically large area will put demands on recording strategies.

With both projects we used wireless microphones and receivers as shown in Figure 11. These provide quality sound pickup, whilst being of little annoyance to the wearer. When taking this equipment into the wood, a range of between 20 to 30 meters could be achieved, and up to 50 metres in the clearings. The frequencies band used by these devices are the same as used by the wireless speakers 863MHz. Cross talk between devices can be experienced with the user data being transmitted onto speakers hidden in the wood. Selection of mutually exclusive frequencies, within this band is a straight forward solution to this.

Figure 11: Wireless microphone receiver and recording device (plus foot)

The recording of video data whilst outdoors necessitates someone walking around with the camera filming points of interest as they develop. This dynamism is especially difficult in woodland where there can be lots of obstacles in the form of twigs, fallen trees and branches to avoid. There is a natural tendency to get shots from behind rather than in front, as children are always moving around with the camera person following behind.

Environmental factors – Design of pervasive environments do not happen in a vacuum. The environments in which the activities take place have implications for the context in which interactions occur and will, to some extent, define the scope of the technology used. Indoor spaces typically exist within tightly controlled environmental parameters; lighting, heating, wind, rain, dust etc, are all managed to some extent with little variance. When putting technology outdoors, these effects become much more significant and provision to adjust for wider variances needs to be taken.

Other attributes of the location can also have bearing on the design. Indoors, it is relatively easy to configure the surroundings, whereas outside the landscape is more fixed. The use, or non use, of naturally occurring features such as ponds or paths must be designed around.

Indoor spaces lend themselves to more ‘generic’ designs - having designed Snark once, it would be very easy to re-use this work with minimal effort. In the outdoor space, each instance has to be specifically tailored to the current factors – the generalisations and re-usable components happen at a much higher conceptual level.

4 Discussion

Much of the vision of ubiquitous computing environments talks about augmenting our everyday world with technologies and devices that become a part of our normal environments. Much of the research that has explored ubiquitous computing issues, however, does so within constrained or purpose-built environments.

In this paper, we have talked about two projects that are very similar in many aspects – providing children with innovative play and learning experiences through orchestrated arrangements of pervasive devices and technologies – yet the experiences of the design team in designing, deploying and maintaining these projects were very different. The staging of Ambient Wood as a fieldtrip with a difference in a real physical wooded habitat posed significantly greater and different challenges to staging the Hunting of the Snark in an indoor lab environment. We often take for granted the resources made available indoors and it is only when these are taken away, as shown when creating pervasive environments outdoors, do they come to light.

Many of the issues and lessons we have discussed, especially coming out of Ambient Wood (organised around technological, logistical and design dimensions) might seem trivial and our solutions might seem simplistic. Yet they also point to very real considerations that are normally not encountered in more controlled or constructed environments, considerations that can have terminal catastrophic effects on the success of any outdoors pervasive computing environment.

Our experiences also point to the need to engage in such projects with a multidisciplinary team with the mix of skills and expertise to deal with issues that will arise. The teams for Snark and Ambient Wood involved people ranging from cognitive psychologists who were concerned with how to design effective and engaging learning experiences for children, to computer scientists who could encode the messaging infrastructure enabling communication in the wireless wood, to graphic designers who could contribute to interface/device design, to engineers who could address power supply and antennae issues.

Our experiences also point to the need to engage in discussions of these issues early and often in the design phase. A multidisciplinary team and concerns that arise from each of the disciplinary perspectives necessarily mean that there will be trade-offs and compromises. What the cognitive psychologist might want to do from an educational perspective might not be feasible from a technical perspective and vice versa.

Finally, the very uncontrollable and unpredictable nature of outdoor environments means that the whole of the design and deployment process needs to remain flexible and responsive to the very end – recall the 'wet run' and the need to have a different trial run to the real run because of different seasonal conditions. Essentially, we have to adapt to the environment outdoors whilst indoors we have the choice to manipulate, build and create things more easily to a predetermined design.

5 Summary

In summary, we have characterised the different issues in staging indoors and outdoors pervasive computing events along technological, logistical and design dimensions. We have drawn attention to our own experiences in these projects because they are issues and experiences that we would like to have had access to in running our own projects. It is hoped that these reflections might prove useful to others who are similarly considering moving ubiquitous computing into our 'real' everyday environment. There are lesson to be learnt here in the wood that will never be learnt in the lab.

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