

# Trust, privacy and relationships in ‘pervasive education’: Families’ views on homework and technologies

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**Abstract.** Extensive educational research discusses the potential for information and communication technologies in supporting homework, but most has focused on providing content. The research in this paper focuses instead on the issues around managing homework and balancing home and school through the capabilities of ubiquitous technologies. As part of our requirements capture we presented three families with demonstrators of ubiquitous computing systems. Our technologies provoked reactions to situated and embedded information capture and access, and locational information capture through mobile devices. The subtlety and complexity of roles and relationships of different family members raised issues around trust and privacy in relation to children’s homework practices. We consider how these drove acceptance of the technologies, and how the contrasts between family and educational relationships produced different requirements for technologies managing information transfer inside and outside the home. Overall, we highlight how respect for these concerns can inform the design of pervasive technologies, particularly within the domestic and educational contexts bridged.

## 1. Introduction

The challenge of integrating pervasive technologies into the domestic environment has been the focus of a wide body of research since the late 1990s [1-3]. Issues surrounding the adoption of these technologies, their social acceptance, and the privacy and security of data collected in the home have both established and echoed general concerns in ubiquitous computing [4-6]. This focus on the domestic context means the majority of this work concerns technologies that capture information to complement and service domestic life – domestic capture for domestic application. These applications have included the development of technologies to link distributed family members, the development of assistive technologies to support “aging in place”, and tools to help with domestic organization and coordination [7-11].

In this paper we will explore the boundary between the domestic and other aspects of life. While many of the existing scenarios of future smart homes have highlighted home and work links we wish to consider an educational perspective. In particular, we will focus on the ways in which future pervasive technologies may be exploited to support children’s homework, school activities set by the school for children, and generally expected to be completed at home, out of school hours. This exploration

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allows us to consider how the lessons of the domestic reach out. How are the established social issues surrounding domestic ubiquitous computing [5] affected when we consider activities that span beyond the home?

Our research into technologies in homework has identified the transfer of information between home and school as a concern for both families and educationalists. The project has involved children ranging from 8-16 in a variety of different family arrangements – in the current paper we focus on a core study with three families with children aged 12-16. Current rhetoric within the educational world claims an ideal use of mobile ICT technologies is to support home-school links [12] and so this is an obvious area where the uptake of pervasive technologies could be imminent, making this a critical time for the pervasive community to examine such claims. Could such ideas actually happen in practice? Are families interested in blurring the boundary between home and school and do they feel ubiquitous computing techniques are an appropriate way to support homework? This research will attempt to address this agenda, by studying pervasive computing within the home and children's homework, and families' reactions to it.

## **2. Ubiquitous Computing and Education**

While there has been little direct research into ubiquitous computing and education, the technical properties of pervasive technologies [6] are complementary to current drives in education to produce richer, personalized learning experiences. Many authors within the area of educational technologies have called for the use of ubiquitous devices in the future of learning [12-14] suggesting that these can allow the seamless integration of both computing, and the education it supports, into everyday life [15-19]. Mobile technologies, with their ability to run context-aware applications, allow the delivery of personalized learning experiences away from school [20]. In both mobile and embedded technologies, the automated capture and access of information about location and activity allow further context-sensitive delivery of learning materials, and the information collected offers both teachers and students the chance to reflect upon learning experiences [14].

In terms of intentional learning at least (as opposed to informal or incidental learning), the majority of children's out-of-school educational activity currently takes place within the home. Homework is interesting from a research perspective because it offers a different lens through which to see (and capture) domestic activity compared with previous studies. What is more, the application of UbiComp in educational domains is still little explored.

In addition to capitalizing on the benefits of ubiquitous computing, education will also need to grapple with the challenges it faces. With the sharing of domestic information outside the home (i.e., in school), the obvious technical issues facing ubiquitous computing include privacy and security of information [21]. We are most interested in the social implications and negotiations needed around capturing and sharing information about the domestic with the outside world. Technology for capturing contextual information about children in the domestic – monitoring their activities and location – is generally used by parents of quite young children – e.g.,

using technologies such as baby monitors to check safety. From the school end, although teachers have been traditionally viewed as *in loco parentis*<sup>1</sup>, we are interested in investigating whether teachers are seen as having the same rights of access to contextual information as parents. This contrast between home and school use will be a driving concern in this paper.

Researchers in education seem content that the benefits of educational improvement will be sufficient for family members to accept and adopt technologies in the home, with most concerns surrounding families' finances and the socioeconomic drivers of uptake [22, 23]. This study will follow from a tradition of work looking at both domestic and educational uses of technology [5, 24-27] inspiring critical consideration of the effects of technologies on such domains of application. We will attempt to bridge the gap between the theoretically focused work of proponents of such technologies, and the more practical studies that do exist, but tend to focus on the academic success of the implementation of a specific device [28, 29]. However, we also wish to identify when and where privacy issues might occur, when sharing information is seen as mutually beneficial [30], and what technological solutions might aid or exacerbate this. In the following section we will therefore report on the reactions of families to a range of ubiquitous computing technologies.

### 3. The Study

This study reported in this paper was informed by several other elements of a three-year research project into technologies in homework, consulting multiple stakeholders from the school and home contexts. Our focus on introducing pervasive technologies into the home-school relationship and the technologies explored within the study arose as a result of a survey of Heads of ICT at 34 local schools and interviews conducted with 6 Heads of ICT from this pool. These interviews identified networks linking home and school as the future of homework activity. In order to assess how this trend might impact homework we looked at the use of traditional homework technologies through video diaries with 8 families and discussion groups with 180 children. Our findings suggested that negotiation of parental access to homework activities with and through homework technologies was often necessary for children, and we wished to see whether negotiation of access would be necessary and manageable in future pervasive computing contexts.

In order to investigate the negotiation of access in more depth, we returned to a school from our study of Heads of ICT, where use of technology to link home and school had already begun. We asked them for feedback on the systems they used, and for general details of their use of technologies in the home-school area. Ten families agreed to speak to us initially and they identified three areas in which technologies were currently used. These were *accessing information through the Internet and school intranet*, *transferring information between home and school*, and *coordinating home and school trips*. The potential links between these issues and pervasive homework technologies drove the selection of three demonstrators of future

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<sup>1</sup> *in loco parentis* allows the school to deal with children in its care as a parent or guardian would.

homework technology use. In order to explore potential use of pervasive technologies to support homework we set up in a tour of our research laboratory for three families, and asked them for feedback and comments on the systems, the ways they might affect home-school links and how these technologies might fit within their homes.

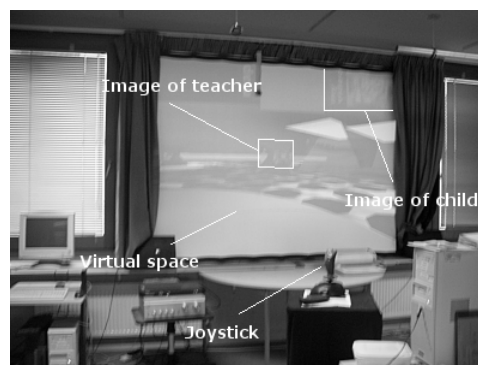
#### 4. The Key Demonstrators

Given our concern with integrating future technologies into the home, we sought to make the demos provocative, emphasizing the range and degree of information that could be gathered about families' lives using pervasive technologies to explore their acceptability. Each demonstrator is described below with short usage examples, the educational motivators and pervasive technologies involved.

##### **Demonstrator 1 - Situated Information Access.**

Our interviews with the families showed that their primary use of digital technology in homework was to access information, mostly through search engines, but that they were unable to efficiently judge the quality of this information. One major benefit of pervasive technologies mentioned by educationalists is its ability to connect users to a variety of specialists. We therefore took ways of improving situated information access through specialist knowledge as the theme for our first demo.

**Mixed Reality Boundary.** *A situated display allows children to navigate around a bazaar of teachers, each offering subject specialties, and clustered together so that the answer of Geography teacher 1 can be compared to that of Geography teacher 2.* As seen in Figure 1, the Mixed Reality Boundary is a situated display that allows the child (pictured top left) to chat face to face with teachers, and navigate around a virtual area, exploring multiple viewpoints and learning from teachers with a variety of expertise. The technology presents a view of an "always on" communication future that allowed us to explore families' reactions to a two-way exchange of information.



**Fig. 1.** The Mixed Reality Boundary. This video conferencing system could be placed on the wall of a home, and used to select and communicate with experts.

Table 1 summarizes the key educational motivations and the key pervasive computing technologies within this arrangement.

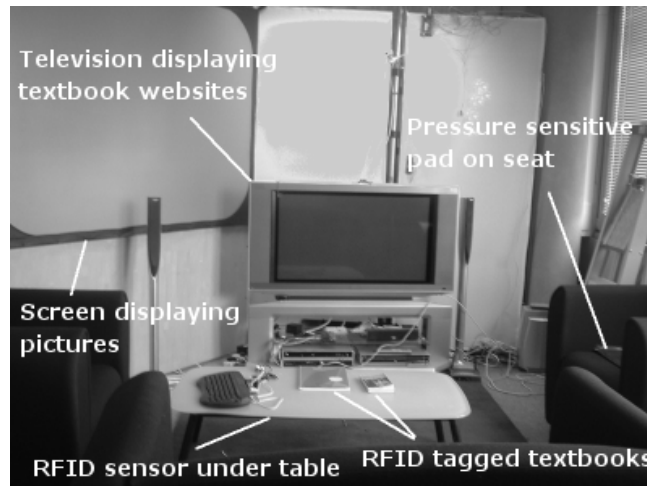
**Table 1.** Educational motivation behind the situated information access demonstrator.

Demonstrator	Educational motivator	Pervasive technology
Mixed Reality Boundary (MRB)	Provides easy access to teachers, who would necessarily provide higher quality material than search engines, and allows children to easily compare multiple viewpoints.	Situated display technologies with video conferencing links.

### Demonstrator 2 - Embedded Information Capture and Access.

Our interviews identified families' discontent with the current school system linking home and school through technology. In particular they felt this was awkward and slow. Another major benefit of pervasive computing expounded upon in the educational literature is its ability to seamlessly transfer contextual information between different settings. We therefore took the transfer of information through pervasive technologies in a 'lounge' within our lab space as our second demonstrator, which illustrated a number of pervasive computing arrangements and use scenarios.

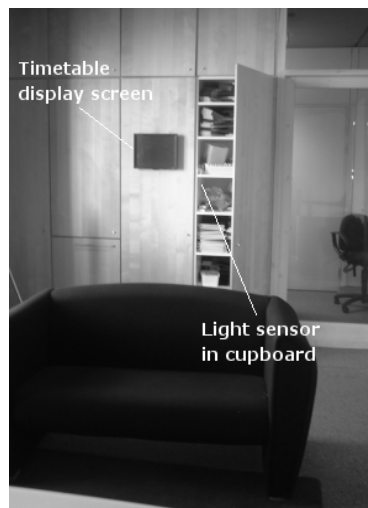
**Intelligent text books.** *A child opens his schoolbag and places a copy of Macbeth on the table. This opens a webpage on his television displaying additional study resources, which end in a quiz for the teacher to assess.* The text books were set up to display webpages with appropriate educational content when placed on the table, as seen in Figure 2.



**Fig. 2.** The Lounge area with screen, pressure sensor and tagged homework resources on table.

**Seat photo capture.** A child sits down to do their homework, and a camera records the information. The picture is sent to the teacher with details of when and where the homework task began, so she can check work is being completed promptly. Here, a pressure sensitive pad was placed on the chair, so it registered when a family member sat down and took a photograph of them, as seen in Figure 2.

**The homework cupboard.** A child comes home after a day at school, and opens the cupboard where his textbooks are stored. The display screen on the adjacent cupboard lights up with his homework task. A light-reactive sensor was placed on the cupboard seen in Figure 3 so it triggered a homework diary on a display on the next cupboard it was opened.



**Fig. 3.** The Lounge area homework cupboard and cupboard display.

These demonstrators allowed us to investigate how children and parents felt about essentially ‘negotiation-free’ transfer of information built into their domestic environments. We wished to establish which, if any, information was deemed suitable for handling automatically in this way. Table 2 summarizes the key educational motivations and the key pervasive computing technologies within this arrangement.

**Table 2.** Educational motivation behind the embedded pervasive technologies.

Demonstrator	Educational motivator	Pervasive technology
Intelligent text books	Pervasive technologies offer the ability to receive record and deliver information based on the child’s actions. RFID tags can exchange information at the trigger of an everyday activity, such as placing homework books on a table. Uses might include sending	RFID tags and sensor embedded within physical artefacts to access digital information.

	reminders or recording children's progress.	
Seat photo capture	As with the textbooks, here information exchange could be triggered by a child sitting down to their desk. The camera shows how information can also be recorded for later.	Pressure sensor and cameras used to support activity based triggering.
The homework cupboard	As with the previous two examples, opening a cupboard or a bag to start a homework task might trigger events.	Light sensor used to track and record activity
Output screens	The output screens offer the opportunity to use children's actions as a cue to display information, such relevant webpages.	Appropriation of screens in domestic settings

### Demonstrator 3 - Locational Information Capture through Mobile Devices.

Our final demo took inspiration from the families' use of mobile phones to communicate and coordinate the journey home from school. It linked together this parental wish to track information with the educational literature's ideas on the use of mobile devices for learning, which have include tracking devices which alert the child (or teacher) to educational opportunities around them.

**Locational tracking.** *A child carries their mobile phone with them, and a tracking system sends reminders and alerts dependent on their location. Their parent notices they are on their way home early, which will allow a change of plans for the evening, making it possible for the child to get their homework done and visit their aunt. The child sees a piece of litter that needs to be recorded for a project, and takes a photograph, with the locational information available to map litter locations at school. This demonstrator showed systems for tracking children and recording information about their location at specific times through a mobile network, with results such as that seen in Figure 4.*

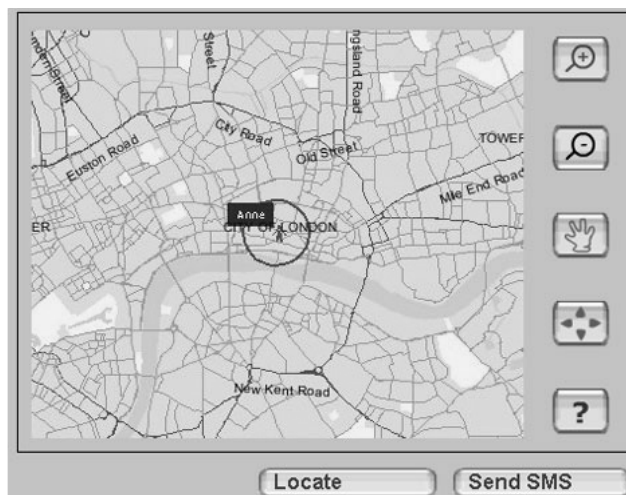


Fig. 4. The Location-based service.

Table 3 summarizes the key educational motivations and the key pervasive computing technologies within this arrangement.

**Table 3.** Educational motivation behind the locational capture demonstrator.

<b>Demonstrator</b>	<b>Educational motivator</b>	<b>Pervasive technology</b>
Mobile phone tracking	When children can be located through a mobile system it allows them to be notified when near a library, or for location-related school projects.	Mobile tracking devices.

## 5. The Families

The families involved in this study were recruited from an independently funded boy's high school, where use of technologies was high in the school and in families' lives in general. We chose this group to ensure a good background in technology use between home and school, and familiarity with the basic concepts behind the demonstrator technologies. The families represent a range of family arrangements and children in different stages of their high school education. This set of families demonstrated diversity in terms of stages of schooling but also the relationships within the different families.

**Family A** consists of a mother, father and only son, aged 12. The father works full time and the mother part time. They own a single computer, placed in a peripheral conservatory, which is used mainly for accessing the Internet and playing games. Technology does not appear to play a central role in the family's life, and television and mobile phones are the only other technologies that are used as routine. The PC was assembled by a close family member, and the father stated it was purchased for the son's education, although he uses it often and the mother occasionally.

**Family B** consists of a mother and father, a son, aged 14, and a daughter, aged 12. Both parents work full time. Family B has integrated technology more fully into their everyday lives. The main family PC is set up in a central position in the lounge. The son has an extensive work and entertainment centre in his bedroom, with PC, digital television and Playstation2. He has been particularly encouraged by his parents to use technologies to overcome difficulties in writing stemming from dyslexia. Again, family members all have mobile phones.

**Family C** is a single mother, a son, aged 14, and a daughter, aged 16. The mother works full time. The family has a television, and a PC, which is well equipped with printer and scanner, but shared within the family, and slow to load. The PC is used extensively and creatively by all the family members, for a variety of home and school projects. It is set up in a corner of the mother's bedroom, and used individually. Each family member has his or her own mobile phone.

## 6. Lessons Learned

Each of the three families started the technology tour at a different demo, and then rotated around each demonstration area in turn. Each family was debriefed after their tour, using a semi-structured interview encouraging them to discuss how they could see these technologies being used generally within a domestic context, and specifically within homework. We also wanted to contrast how these information types were seen for home use and school use, so asked families to discuss how both parents and teachers might benefit from them. In this section we wish to present the key lessons to emerge in terms of three key themes

- The link between the pervasive information capture and interpersonal relationships.
- The impact of emerging rights and responsibilities within family structures.
- Managing access to those outside the family.

Key comments from the families are presented within this paper as verbatim quotes from interview logs, contextualized within conversations, in order to illustrate these themes in depth. Initial reactions to the technology were positive. Families welcomed the use of new technologies, particularly within an educational context, as can be seen in their attitude to the embedded sensor technologies:

*“Good, because the book’s there and then you don’t get in detentions or whatever, because you know, you know that you’ve brought the right books in and everything” [son, Family A].*

We also noted that the mobile location technologies were received with slightly more scepticism than others, but families still acknowledged their practicality:

*[father] “It’s good, but, er, they can turn the phone off, so then you can’t find where they are, so if they go somewhere where they’re not meant to be then they can just turn the phone off and then it won’t be finding them”*  
*[interviewer] “Yeah, so you can trick your parents into not finding you”*  
*[father] “You wouldn’t do that, would you? No, we thought it was a good idea, didn’t we?” [Family A].*

These reactions suggest that the face value of such technologies is clear to families, and ties in with the educational rhetoric that practical applications of pervasive computing technologies will avoid concerns. Further conversation, however, elicited deeper concerns. Our analysis drew out the three themes we use to consider how families felt pervasive technologies might influence relationships and negotiation. The first two explicitly examine family relationships between individuals and as a whole. The last looks at relationships between the family and the outside world.

### 6.1 Information Capture and Interpersonal Relationships

Situated information capture involving seamless and non-negotiated capture of information was seen as acceptable within the context of certain relationships in the

home. Ubiquitous devices could monitor the ‘vulnerable’, in the context of relationships established to ensure safety. In keeping with previous research, the very old or the very young were seen as candidates for this kind of care:

*“any person that you feel might be vulnerable, you know, living on your own”*  
[father, Family A]

Within the families, we focused on the relationships between our parents and children. The acceptability of capturing information about day-to-day life, particularly within homework, seemed linked to the emerging roles of children as independent adults as they grew up within the family settings. As we look across our families a pattern of acceptance, resistance, and finally rejection of parental access to children’s lives seemed evident as children grew older. The only son in Family A, at age 12, seemed to be quite accepting of information capture in his day-to-day life:

[father] *“I think it’s getting used to doing that instead of just picking up the phone and dialling... punching his number in”*  
[interviewer] *“Would you take long to get used to it? How would you find it?”*  
[son] *“I wouldn’t feel like I was being tracked [on] really”* [Family A].

In Family B the elder son, aged 14 talked about resisting information capture:

[mother] *“they’ll not be able to say to you ‘well, no, I did loads’ when they didn’t.”*  
[interviewer] *“And how would you feel about that kind of thing then?”*  
[son] *“I like being able to lie about it!”* [Family B].

In Family C, however, where the eldest child was a 16-year-old daughter, both daughter and mother rejected the capture of information about her life, suggesting that pervasive technologies would not only be useless, but also inappropriate:

*“you know if she was out on a Saturday night, it probably is better that I don’t know!”* [mother, Family C].

These differences suggested that the parent-child dynamic changed as time went by, something that was also explicitly mentioned in our interviews:

*“obviously when he gets older, when he’s out with his girlfriend and stuff, he doesn’t want dad: ‘where are you?’”* [father, Family A].

**Relationships and Trust Change Privacy of Information.** The definition of personal or private information differs according to relationships, as has been shown in other research into social networks [31]. We found that carers had the strongest right to capture information, whether caring for the generally vulnerable, or for their own children. This suggests that the parent-child relationship, where parents are seen as the ultimate ‘carer’, should support the automatic transmission of information more readily than the teacher-child relationship. However, even within-family monitoring is not a simple concept. As children became older, the role of a parent as carer becomes more blurred, and more information is viewed as personal, private, or generally inappropriate for capture. The relationship has to be constantly renegotiated and evolves. The effect of this emerging role of teenagers is enhanced in a context like the

management of homework, which is notoriously sensitive [32]. The changing roles of children as they become teenagers are well established. Here, however, the elements of trust implicit in carer relationships are applied to the capture of information where inflexible technologies might make it difficult to allow this relationship to grow with the children.

## 6.2 Rights, Responsibilities and Family

Within the family, rights [33] and responsibilities [34] create a complex social environment for sharing information. Trust between parent and child facilitates the sharing of such information. For example, families saw the potential of tracking, as with current mobile use, for coordination – two-way sharing of locational data, rather than one-way monitoring. This is contrary to previous research which suggested that mobiles are primarily a one-way monitoring, even if a two-way negotiation tool [35]:

*“it would probably minimise the phone calls of ‘where are you? how long are you gonna be?’ them sort of things, erm, and like for us, to know when we’ve left work, or I’m still at work” [mother, Family B].*

However, these were non-homework related examples. Although the trust relationship could lead to families trading information freely, demanding information about a child’s homework activities could suggest a lack of trust. Both parents and children were concerned that use of captured data might violate the rights of children, and felt that reliance on information capture subverted the idea that a child should and could take responsibilities for their actions, especially in a homework context:

*“I think it’s really mostly the child’s responsibility, that they have to take responsibility really, and it shouldn’t always be up to the parents to make them do it, and they should accept the consequences” [son, Family C].*

Reactions to such a violation differed from family to family. For example, the 14-year-old boy in Family B protested far more than the 14-year-old boy in Family C, with conversation in Family B focusing on the boy wishing to maintain privacy, and in Family C more on the boy’s responsibilities. What is more, rights were not always earned by a display of increased maturity, as the daughter from Family C shows:

*“isn’t it breaking a bond of trust, if you can’t trust them to do that, and... I think it’s, it’s just part of growing up that you don’t, you don’t do it [homework]... I just hate the fact that it would be completely controlled” [daughter, Family C].*

**Trust Works in Mysterious Ways.** While trust levels in the family were higher than those outside, this did not always lead to acceptance of ubiquitous information capture and disclosure. With children coming into adolescence, as with our group, both locational and activity recording technologies were seen as the right to privacy and the need for the child to take responsibility for their actions. Similarly, the adoption of responsibility by the child could be compromised by implying a lack of trust in this way. The interviews certainly suggested that information capture and disclosure between parent and child generally needed to decrease as time went by, and mobile

and personalized technologies do offer the ability to configure information capture and disclosure in this way. However, we must ask how such configuration would be implemented, with the effect of age overshadowed by individual family relationships.

**Technologies Make Relationships Explicit.** Familial trust around information access and capture is certainly heavily situated. Trust is necessary for the sharing of information, but demanding the sharing of information can violate trust. There is an arrangement between parent and child that demands responsibility, and conveys rights, but when children avoid responsibility or parents ignore rights, the arrangement is flexible and seems to acknowledge that children are still in training as adults. Homework is cited as a core example of this training, where children were learning to take responsibility for their own actions. The complexities of responsibility have been explored in sociological literature [36], but what do they mean for technological design? Such complexities were presented to our interviewers as unproblematic facts of everyday life. Trust is not just negotiated in a highly complex and situated manner within the family but rights and responsibilities are also more intimate, and may be instinctively rather than explicitly negotiated.

However, introducing configurable tools to manage information sharing requires explicit rules, so here designers face a large challenge. Suchman [37, 38] has argued that technological attempts to make interactions explicit – accepting or denying access to information being such an example – can highlight both the tool and the natural social process, causing breakdowns in relationships and actions. Making technologies configurable may make these interactions even more explicit. For the transmission of homework information within the family, this might be addressed by allowing space within the design for social solutions to the problem, allowing the signal sent through the technology to be ambiguous, giving the user the space to create socially acceptable stories around these signals [31, 39, 40]. On top of this, the constantly evolving nature of relationships can be accommodated in such processes by the constant renegotiation of relationships.

### 6.3 Managing Access to Outside the Family

We have discussed the complexity of information sharing within the family. Lastly families considered the exchange of information with the outside world. Here trust was lower. Families were sceptical that information gathered by environmental sensors or mobile devices would remain under their control, and even though the demos we showed them were mostly configured to transfer information into rather than out of the home they felt that the information was inevitably vulnerable:

*“you’ve got a database so people can watch what you’re doing” [son, Family B].*

However, it was not just the dangers of unnamed malicious parties families had privacy concerns about. Reactions to the Mixed Reality Boundary (MRB) showed that even when teachers were involved, allowing access to the home put a completely different slant on the acceptability of technology:

*[daughter] “Erm, it didn’t feel intrusive, because it was just... if it was in homes or something, I think it would”*

[interviewer] “Yeah, so we’re talking about this TV screen being able to do the same sort of thing, so we could actually go...”

[daughter] “In your home?!”

[interviewer] “In your home, or, or in your classroom, or...”

[daughter] “I think it’s a fun concept”

[interviewer] “Right”

[daughter] “But I wouldn’t like it in my own home!” [Family C].

The only way in which domestic information would be shared was with strong family control of disclosure, as with this response to sharing homework tasks:

*“I think the essential thing is switching it on and off” [mother, Family C].*

Lastly, from the families’ discussion of sensors it seemed that educational uses were only acceptable when providing strong incentives, i.e. diagnosing difficulties:

*[mother] “if there’s a record of what textbooks have you looked at ... if you’ve then got a poor mark in a test that you’ve got proof that you’ve really revised hard for, then you know that there’s some underlying problem.” [Family B].*

The contrast between views on information sharing within and outside the family was particularly strong with mobile devices. As discussed before, families saw coordination as important for parents and children’s social interactions, but were reluctant to draw this into homework. What is more, no family was open to sharing this information with schools, as with previous media coverage [41].

**The importance of information type.** Negative reactions to sharing domestic information increased as this information became more personal and situated. What made some information more sensitive than others? Currently available search technologies were viewed positively – these tend to collect aggregated, low-fidelity information about activities. However, in our more provocative demos, we exposed families to domestically located, detailed, temporally stamped information, and strong negative reactions were seen. This viewing of some high-fidelity data within the domestic as highly personal replicates findings in other studies of information capture in the domestic environment [11]. The Mixed Reality Boundary, which transmitted visual, temporal, and some locational information was seen as our most controversial technology, a common theme for video media spaces [42]. However, its use within a library or classroom was totally accepted, confirming that privacy is not just about the type information sent, but the place of the home. Similarly, sharing of personal locational information was not even considered outside the family. We suggest that the particularly strong reaction against the use of this technology outside the home is because locational information is always considered personal and private, based on extreme reactions to locational information even in locations like schools [41].

**Situated Control of Personal Information is a Necessity.** A database was seen as a threatening record, with fear about the ability to control captured information high. Even strong educational scenarios in the sensor and information finding demos, while acknowledged as useful, did not overcome these concerns. The family was the only group who were trusted to both receive and use personal information without filtering.

However, this was in a limited range of circumstances – such as with children trusted to track parents as much as vice versa. The model transfers poorly into more one-sided homework sharing. When it came to controlling the sharing of homework information through technologies, only the family was trusted to control disclosure of domestically situated information. Technologically based solutions to disclosure we discussed with families such as security filters were rejected. Simple controls were demanded, and seemed to be the best ways to assure families of safety. To achieve this, designers need to ensure visibility of processes – for example, using awareness tools to show families how the information gathered in their home is transmitted and to allow them to manipulate a good working model of the network and its devices.

## **7. Conclusions**

This study has explored the acceptability of ubiquitous computing technologies to support homework within a group of families, and has been undertaken as part of a long-term engagement with a range of families. Within this paper we have presented reactions to three distinct technological scenarios. These highlight a number of distinct conclusions of broad interest to the pervasive computing community and those interested in the application of advanced technologies within education.

### **The Domestic and ‘Ubiquitous’ Education**

In seeking to deploy pervasive technology in domestic settings to establish stronger links between the home and educational settings of our children we are infiltrating an environment in which a complex series of values are already present. One of the core challenges that has already been identified in this move to domestic settings is understanding the social implications of pervasive technologies [5]. We have described how the sharing of information gathered inside this environment with external agents such as teachers provides an expanded set of issues surrounding privacy and relationships, be they interpersonal, or within and without the family. Alongside calls for an increased use of ubiquitous technologies in education, this has established the transfer of educational information within and outside the domestic as an important area for research.

The differences between domestic and educational contexts and the effect this has on the reception of ubiquitous computing have been clear. We have shown that trust is constantly expected between parent and child in the family: such implicit trust arrangements are unlikely to exist in schools, where it is usual for children to be monitored through assessment and attendance records. Although we do not mean to suggest that trust is absent between teacher and child in school, it is often negotiated at the interpersonal level, rather than accepted school-wide. These core differences suggest that domestic and educational contexts will clash in the messages they send to children, and designing pervasive technologies to adapt to this difference is a complex challenge.

## **Ubiquitous Computing and Education**

References to roles, rights and responsibilities in this article have emphasised that there are many social restraints on the immediate adoption of ubiquitous computing in education. Some of the difficulties in using technologies that share information about domestic contexts with educationalists might be tempered by including social norms in the process that mirrors those seen in the home.

For example, trust and coordination seemed to be the basis on which family members shared information. By framing ubiquitous computing technologies as coordinating between teacher and child, trust might be established on a more equal footing, and the acceptability of such devices in home-school relations increased. There is a choice to be made here between replicating the relationship between children and parents – allowing a great deal of information to be shared, but demanding some degree of reciprocity – and settling for highly controlled information exchange, which current models of schooling support.

Children's increased control of education is the principle behind introducing ubiquitous technologies into education. However, increasing the autonomy of children may not be always about allowing them to choose the learning content and support they access, but also about allowing them to negotiate when and how to access learning resources. When using technologies as a way of making education more ubiquitous, we need to consider both the control of information sharing, and the control of educational infiltration. This is particularly true in domestic contexts, where research has become more focused on the ludic [43] and the difficulties of transferring work (and presumably educational) principles and technologies into the home.

## **Guidelines for Design**

Basic guidelines for ubiquitous computing design can also be gathered from this work. Although much of our work has taken a cautionary tone we believe these represent a positive contribution to the development of technologies in this area.

We have discussed that information sharing within the family is a highly sensitive issue, and when insufficiently negotiated between relevant parties, it can undermine trust, responsibilities and rights. However, we wish to establish that in the family, privacy and trust go beyond simple information control. While configurable devices are one way to address this problem, they rely solely on controlling the information captured, and not on supporting established relationships. The complicated interactions of family members appear impossible to model or support with technological controls, making technological solutions to privacy and control an inadequate solution to the problem. Allowing families to negotiate their own solutions while children adjust to new rights and responsibilities – as they have, unaided, for many years, may avoid situations where making such interactions explicit could cause issues. As designers our best strategy for transmitting homework information seems to be to allow within-family signals to be ambiguous and interpretable.

The contrast comes when homework information is shared with the school. Visibility and control of technologies were core demands of families when sharing information with the outside world. Families were apprehensive about the recording

of data about their everyday lives, with an obvious solution to this being explicit highlighting of the channels through which this data travels and mechanisms for controlling this. We have discussed that this reflects current models of trust between child and teacher, rather than a necessary condition of their future relationship.

Our last comment must be on the importance of context in framing the sensitivity of and manipulation of information. Avoiding sensitive types of information is a way to sidestep issues, with our findings suggesting that the capture of temporal, visual and locational information might best be avoided where possible. However, we can also repurpose, rather than reduce this information, with the positive effects of trust in the family suggesting wider opportunities for increasing the acceptability of pervasive technologies. Social steps such as these, or more local workarounds where we are limited in our technical solutions, such as increased control of devices or the space for social negotiation of device use, are applicable across domestic, educational, and many more contexts. The challenge for pervasive computing is the design of technologies that allow flexible social negotiation and are able to span the more fluid world of the home and the structured setting inherent within our educational environments.

## References

- [1]Crabtree, A. and Rodden, T. (2003). Finding a place for UbiComp in the home. In Proceedings of UBIComp, Seattle, WA, USA: Springer-Verlag.
- [2]O'Brien, J. and Rodden, T. (1997). Interactive systems in domestic environments. In Proceedings of DIS, Amsterdam, The Netherlands: ACM Press.
- [3]Mateas, M., et al. (1996). Engineering ethnography in the home. In Proceedings of CHI: ACM Press.
- [4]Hong, J.I., et al. (2004). Privacy risk models for designing privacy-sensitive ubiquitous computing systems. In Proceedings of DIS, Cambridge, MA, USA: ACM Press.
- [5]Edwards, W.K. and Grinter, R.E. (2001). At home with ubiquitous computing: Seven challenges. In Proceedings of UBIComp Conference: Springer.
- [6]Abowd, G.D. and Mynatt, E.D. (2000). Charting past, present, and future research in ubiquitous computing. *ACM Transactions on CHI*, 7(1): p. 29-58.
- [7]Mynatt, E.D., et al. (2001). Digital family portraits: Supporting peace of mind for extended family members. In Proceedings of CHI, Seattle, WA, USA: ACM Press.
- [8]Dalsgaard, T., et al. (2006). Mediated intimacy in families: Understanding the relation between children and parents. In Proceedings of International Conference for Interaction Design and Children, Tampere, Finland: ACM Press.
- [9]Vetere, F., et al. (2005). Mediating intimacy: designing technologies to support strong-tie relationships. In Proceedings of CHI: ACM Press.
- [10]Mynatt, E.D., Irfan, E., and Rogers, W. (2000). Increasing the opportunities for aging in place. In Proceedings of ACM Conference on Universal Usability, Arlington, Virginia, US: ACM Press.
- [11]Beckmann, C., Consolvo, S., and LaMarca, A. (2004). Some assembly required: Supporting end-user sensor installation in domestic ubiquitous computing environments. In Proceedings of UBIComp, Nottingham, UK: Springer.
- [12]Green, H., et al. (2005). Personalisation and digital technologies. *Nesta Futurelab*. p. 1-29.
- [13]Taylor, J., et al. (2004). An E-learning Research Agenda. EPSRC, ESRC and E-Science. p. 1-9.

- [14] Ainsworth, S., et al. (2005). Cyberinfrastructure for Education and Learning for the Future: A Vision and Research Agenda. A. Bernat, J. Smith, and D. Rothschild, Editors, Computing Research Association. p. 1-40.
- [15] MacKinnon, K.A., Yoon, S., and Andrews, G. (2002). Using "Thinking Tags" to improve understanding in science: A genetics simulation. In Proceedings of CSCL, Boulder, CO, UK.
- [16] Mazalek, A., Davenport, G., and Ishii, H. (2002). Tangible Viewpoints: A physical approach to multimedia stories. In Proceedings of ACM Multimedia Conference, Juan-les-Pins, France: ACM Press.
- [17] McNerney, T. (2004). From Turtles to Tangible Programming Bricks: Explorations in physical language design. *Personal and Ubiquitous Computing*, 8(5): p. 326-337.
- [18] O'Malley, C. and Stanton Fraser, D. (2005). Learning with Tangible Technologies. In Literature Review Report, Nesta Futurelab: Bristol, UK.
- [19] Price, S., et al. (2003). Using 'tangibles' to promote novel forms of playful learning. *Interacting with Computers*, 15: p. 169-185.
- [20] Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers and Education*, 34: p. 177-193.
- [21] Proctor, T. (2005). Data security threats in the home environment. In Proceedings of IFIP WG 9.3 Home-Orientated IT (HOIT) Conference, York, UK: IFIP.
- [22] Lewin, C., Mavers, D., and Somekh, B. (2003). Broadening access to the curriculum through using technology to link home and school. *The Curriculum Journal*, 14(1): p. 23-53.
- [23] Valentine, G., Holloway, S., and Bingham, N. (2002). The digital generation?: Children, ICT and the everyday nature of social exclusion. *Antipode*, 34: p. 296-315.
- [24] Palen, L. and Dourish, P. (2003). Unpacking 'Privacy' for a Networked World. In Proceedings of CHI, Ft. Lauderdale, Florida, USA: ACM Press.
- [25] Selwyn, N. (2000). The National Grid for Learning: Panacea or Panopticon? *British Journal of Sociology of Education*, 21(2): p. 243-255.
- [26] Land, R. and Bayne, S. (2002). Screen or monitor? In *Improving student learning using learning technology*, C. Rust, Editor. OCSLD: Oxford, UK. p. 125-138.
- [27] Greenfield, A. (2006). *Everyware: The dawning age of ubiquitous computing*. Berkeley, CA, USA: New Riders.
- [28] Luckin, R., et al. (2005). Using mobile technology to create flexible learning contexts. *Journal of Interactive Media in Education*, 22: p. 1-21.
- [29] Hughes, M., et al. (2003). Exchanging knowledge between home and school to enhance children's learning in literacy and numeracy. In Proceedings of ERNAPE Conference, Poland.
- [30] Brin, D.G. (1998). *The transparent society: Will technology force us to choose between privacy and freedom?* Reading, MA, USA: Perseus Books.
- [31] Iachello, G., et al. (2005). Developing privacy guidelines for social location disclosure applications and services. In Proceedings of Symposium On Usable Privacy and Security (SOUPS), Pittsburgh, PA, USA: ACM Press.
- [32] Solomon, Y., Warin, J., and Lewis, C. (2002). Helping with homework? Homework as a site of tension for parents and teenagers. *British Educational Research Journal*, 28: p. 603-622.
- [33] Davies, S.G. (1997). Re-engineering the right to privacy: How privacy has been transformed from a right to a commodity. *Technology and Privacy: The New Landscape*, Ed. P. Agre, E. and M. Rotenberg. 1997, The MIT Press: Cambridge, MA, USA.
- [34] Such, E. and Walker, R. (2004). Being responsible and responsible beings: Children's understanding of responsibility. *Children and Society*, 18: p. 231-242.
- [35] Williams, S. and Williams, L. (2005). Space invaders: The negotiation of teenage boundaries through the mobile phone. *The Sociological Review*, 53(2): p. 314.

- [36]Solomon, Y., et al. (2002). Intimate talk between parents and their children: Democratic Openness or Covert Control. *Sociology*, 36(4): p. 965-983.
- [37]Suchman, L. (1994). Do categories have politics? *Computer Supported Cooperative Work*, 2(3): p. 177-190.
- [38]Suchman, L. (1987). Plans and situated actions: The problem of human machine communication. *Learning in doing: Social, cognitive and computational perspectives*, Ed. R. Pea and J. Seely Brown. Cambridge, UK: University of Cambridge.
- [39]Boehner, K. and Hancock, J.T. (2006). Advancing Ambiguity. In *Proceedings of CHI*, Montreal, Quebec, Canada: ACM Press.
- [40]Aoki, P.M. and Woodruff, A. (2005). Making space for stories: Ambiguity in the design of personal communication systems. In *Proceedings of CHI*, Portland, Oregon, USA: ACM Press.
- [41]'Student ID badges raise privacy issues' (2005). Fox News. <http://www.foxnews.com/story/0,2933,149814,00.html>. Access 14 November 2005.
- [42]Boyle, M. and Greenberg, S. (2005). The language of privacy: Learning from video media space analysis and design. *ACM Transactions on Computer-Human Interaction*, 12(2): p. 328-370.
- [43]Gaver, B., Dunne, T., and Pacenti, E. (1999). Cultural Probes. *Interactions*, 6(1): p. 21-29.