User Experiences with Mobile Supervision of School Attendance

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Abstract—**This article presents a field study arranged at a Finnish primary school where two classes and a total of 23 pupils between the ages of 6 and 8 trialed an attendance supervision system supported by Near Field Communication (NFC) technology. In the trial the pupils marked their arrival at and departure from school by touching a reader device or a NFC-enabled mobile phone with a contactless smart card. Parents were able to get their children's attendance details via an online 'citizen's portal' and through text-messages sent to their mobile phones. The system was designed to simplify attendance monitoring and to replace teachers' manual roll calls. Information about user experience was obtained by using a variety of data collection methods. We evaluate how various aspects identified in new technology adoption affect the design processes of home-school interaction systems by examining the findings from the viewpoint of three end-user groups (children, parents and teachers). Our analysis also shows that a technology supported attendance supervision system can bring value for all end-user groups but it seems that the system will serve primarily the teachers and the parents.**

Keywords-Near Field Communication; attendance supervision; school; children; technology adoption; user experience; value-based design

I.   INTRODUCTION

This paper introduces a Near Field Communication (NFC) supported school attendance supervision system for school children. Traditionally, teachers conduct pupils' attendance monitoring every morning with manual roll calls, and mark absences and delays in the backend system. This requires time and effort on every school day, which is taken away from teaching. In addition, children beginning school in Finland travel to school largely independently, either on foot, by bicycle, or by bus. Therefore, parents of young pupils regularly call to their child's or teachers' cell phones to ensure that the child has made his/her way to school safely. Answering parents' calls takes up teachers' time that could be used for teaching. The NFC-enabled school attendance supervision system has been designed to simplify attendance monitoring. The system replaces manual roll calls and gives parents information of their children's attendance in real-time.

Related work is described in the next section. Then the research setting is outlined, describing the NFC technology and the developed attendance supervision system. This is followed by the procedures used in the system design with a description of research objectives. The paper continues by introducing methodology used in user experience data collection, and represents and analyzes the field study results. The paper finishes with a discussion and conclusion.

II.   RELATED WORK

Developments in networked and mobile technologies now provide us with more methods than ever for supporting children in their transition between home and school [3]. For example, locational systems can be used to make sure that children are safe on their way to school [4]. Jernström [4] introduces a solution called The Smart-its child Surveillance System, SiSSy, that is an approach to tag children and parents with Smart-Its devices which can sense the environment and determine whether a situation is dangerous or if the child is engaged in something hazardous.

In a study by Fraser et al. [3], family members saw journeys between home and school as an important transition and a big issue for parents in managing their children's time. Information transfer between home and school was also raised as an important matter. Families' reactions to home-school technologies were enthusiastic; they saw benefits in the increased availability of information that can be gained through these technologies. While parents were worried about their children, they suggested that technologies that monitored children's activities, such as the mobile phone tracker and sensors, moved from expressing concern to expressing distrust as children aged. In consequence, Fraser et al. identified as one core issue for future research the discussion of children's privacy in technological design. Not only are there safety concerns about the protection of data collected about children, but also ethical concerns about the rights of children in gathering it. For example, how do we justify increasing links between home and school, when children are often active in resisting such information transfer [5]?

Denmark is traditionally presented as a country where children are able to freely move around and have independent mobility to schools and leisure facilities [11], and Finland can be considered similar to Denmark when it comes to children's mobility. Children beginning school in Finland travel to school largely independently, either on foot, by bicycle, or by bus. A Danish survey by Fotel and

Thomsen [11] states that parents' supervision of children's mobility is bound up with different aspects of their travel conditions, such as the choice of mode of transport. Driving a child, for instance, clearly supports the physical supervision of children's mobility, whereas bicycling or walking can be performed by the child on his/her own and thus leaves room for unmonitored movement.

While statistics show a reduction in the number of road accidents involving children during the past decades, Danish parents report an increase in their concerns about their children's road safety [12]. On top of monitoring children's mobility through escorting them by car or other traffic modes, some Danish parents also monitor their children's mobility from a distance [11]. New technology has made it possible to monitor children by e.g., their cellular phones, and some parents use that deliberately in situations where the children are testing the boundaries of where they can go independently. Monitoring children's movements from a distance seems to provide some parents with a feeling of control and thus seems to ease their risk worries, even though parents' opportunities to save the child from any danger are limited [11]. Fotel and Thomsen [11] state that even though monitoring the mobility of children is often done with a caring rationality, it can transform into a control, which in some cases, the child does not benefit from.

In a small town in the United States a public school children's whereabouts on campus were monitored by a system that used RFID (Radio Frequency Identification) technology. Children wore badges around their necks that contained a photo, grade level and name of the pupil. Within the badge was a chip with an antenna attached. As the chip passed underneath a reader mounted above the classroom door, it transmitted a 15-digit number, which was then translated into the pupil's name by software contained in a handheld device used by teachers to check attendance. Several parents complained that their children's privacy rights were being violated; while the school board defended the system by saying it would keep children in school, free up more time for teachers to teach and increase security for pupils and teachers. The proposal died after protests by parents and privacy and civil-liberties advocates, including the American Civil Liberties Union (ACLU). [6]

Also a Rhode Island school district has announced a pilot program to monitor pupil movements by means of RFID chips implanted into the schoolbags of 80 children. Each chip would be programmed with a pupil identification number, and would be read by an external device installed in two school buses. The buses would also be fitted with GPS (Global Positioning System) devices. Parents or school officials could log onto a school Web site to see whether and when specific children had entered or exited which bus, and to look up the bus's current location as provided by the GPS device. The RFID tag would contain only an ID number, not a name, address, or other personal information, so unauthorized individuals are prevented from gaining an access to pupils' private information. The ACLU has criticized the plan as an invasion of children's privacy and a potential risk to their safety. [7][8]

Qvortrup [9] and Rasmussen [10] argue that the increased protection of children by monitoring them is a central characteristic of modern childhood and we do not yet know all the consequences. According to Rasmussen [10], the possibility of impersonal supervision performed from a distance reduces children's privacy even more, and while some parents approve of it, the majority oppose its prevalence. Williams et al. [13] have presented that society could now perhaps openly question whether (urban) parents are good parents if they don't know where their children are and what they are doing at all times and don't have control over them. Aitken [14] shows how some parents employ a policy of constant supervision of children even up to early teenage years while in any outdoor space. Furedi [15] and Rayner [16] both point out the damage to children and childhood this 'paranoid parenting' might be doing and call for parents to allow children to take more risks.

III.   RESEARCH SETTING

The attendance supervision trial supported by Near Field Communication (NFC) technology began in Oulu, Finland on September 2008, continuing until December 2008. The trialing phase lasted 14 weeks. The trial was conducted at a local primary school, where two classes with a total of 23 pupils between the ages of 6 and 8 (the majority just starting at school), participated in the trial. Parents' permission for their children to participate in the trial and to the adjacent research had been asked in advance. One of the participating classes represented a first grade class (16 children out of 19 participated in the trial; 9 girls and 7 boys) and the other one was a special-needs class consisting of special-needs school children (all 7 boys, 4 first-graders and 3 second-graders, took part in the trial) who were diagnosed with minor special-needs, such as dyslexia, difficulties with concentration or troubles with perceptive skills. At the same time, a similar kind of study was done at a local secondary school with more advanced technology and more complicated application features.

Curtis et al. [28] have argued that disabled children, children excluded from school, and children for whom the discursive nature of conventional interview-based research is less accessible have been less well represented in participatory research than children who are easier to interview. For a range of methodological and practical reasons, children who communicate well, or who are regular school attendees, are more likely to be given a voice in the research literature [28]. Therefore, the class with special-needs children was chosen to participate in the trial along with the 'normal' first grade class.

A.   NFC Technology

Touching with a mobile terminal has been found to be an intuitive, natural and non-ambiguous interaction technique that does not incur much cognitive load for users [17]. Välkkynen et al. [18] state that touching is an effortless way to select objects in the environment and easy to learn and use. Near Field Communication (NFC) technology is designed to make communication between two devices very intuitive. NFC is a very short-range wireless technology that

allows electronic devices to interact with other devices simply by touch. The main advantages of NFC are the simple and quick way of using it and the speed of connection establishment

NFC is based on existing radio frequency communication standards, so it is a special case of implementation of RFID technology. The touch-paradigm prevents reading from a distance because a short physical proximity (a couple of centimeters) is needed to transfer information. Even though NFC technology uses a touch-paradigm, it is technologically possible to read information through NFC from a distance with special powerful reader devices. However, in this paper, we assume that NFC is used through a touch-based interaction paradigm. In our attendance supervision field study, we explore a usage scenario where NFC-enabled mobile phones and smart reader devices located in the classrooms are used to read information stored on pupils' contactless smart cards.

B. System Description

Designed to simplify attendance monitoring and replace manual roll calls, the NFC attendance supervision system does not require teachers to mark absences in the backend system thus leaving more time for teaching. In Figure 1 an overview of the attendance supervision system at school and in extended day care programs is shown.
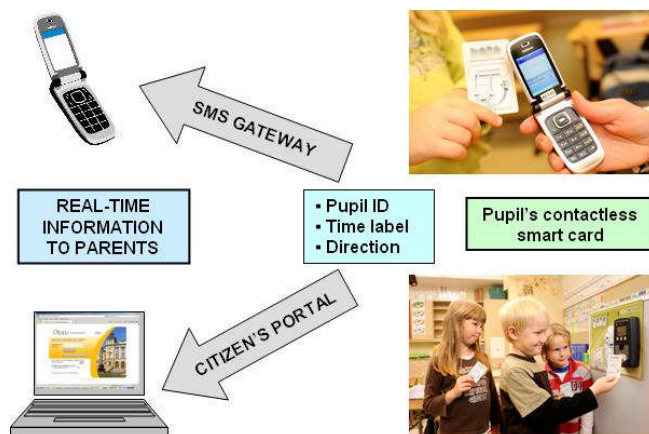

Figure 1.   Overview of the NFC school attendance supervision system.

In the attendance supervision trial pupils were given contactless smart cards named "Robo" containing the pupil's ID. Upon arriving at school pupils in the first grade class 'logged in' by touching an NFC smart card to an active card reader device and pupils in the special-needs class logged in by touching an NFC-enabled mobile phone. The reader devices recorded the card ID (the child's name), the direction (arrival at school) and a time stamp in the backend system. The active reader device was chosen for the first grade class because it works faster than an NFC-enabled mobile phone for large groups. The application in both the reader device and the mobile phone recorded the time of the login; it was possible to choose the 'direction' of the pupil registration (in or out) through both devices. At the end of the school day

pupils touched the reader devices again to mark their departure.

The attendance supervision system (through NFC phone) was also used in extended day care programs where some children went after school. The day care is held in another building outside the school, so with the help of the supervision system parents were also able to follow how much time it takes for their child to walk to the day care from the school (the time between logging out at school and logging in at day care) and to ensure that their child has safely made his/her way from school to day care.

Figure 2 explains the functionality of the school attendance supervision scenario.
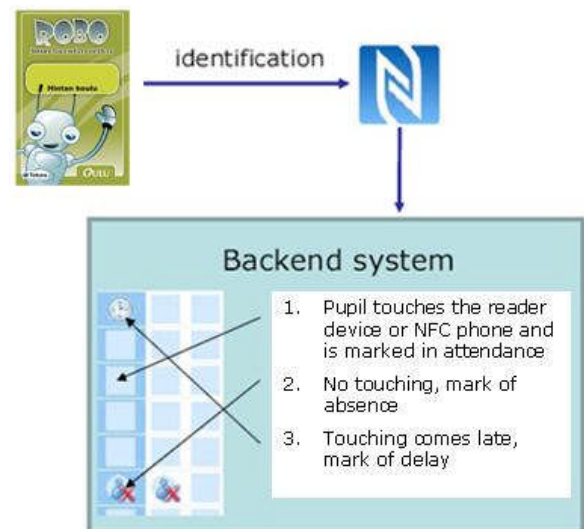

Figure 2.   Functionality of the attendance supervision scenario.

The log of arrivals and departures was automatically compiled by a backend system, and could be read by a teacher in a classroom in real time. If a login did not occur, the pupil was marked absent by default. If a pupil logged in late, the backend system recorded the lateness. Parents were able to get information of their children's attendance details via an online 'citizen's portal' and through text-messages sent to their mobile phones. The system prevented truancy by informing tutors, administrators, and parents of absences in real time, enabling instant intervention.

C. Design Procedure and Research Goals

The attendance supervision concept was planned and designed in close cooperation with teachers, service and technology providers, and researchers. During the design phase the ultimate goal of integrating the concept into normal school practices was especially emphasized, so that the trial would not be an extra effort related to the research project. The aim was to create a viable concept that could also be adopted in the school as a routine to be used after the research trial. This required close involvement of teachers and school administration in planning and implementing the applications, and in organizing and supervising the trial. It was also seen very important that children were given a possibility to participate in the system design to empower

them and get them committed to the use of the system. For example, children participated in the visual design of the system. Information security and privacy issues were also considered in the system design, and precautions were taken to minimize the associated risks. The contactless smart cards only contained a pupil's ID number, not any personal information other that the printed name on the card surface. In addition, in order to handle the pupils' attendance data as confidentially as possible, access to this data online was put under password protection and text-messages about the pupils' attendance details were sent only to parents' authenticated mobile phone numbers. These measures were taken to prevent unauthorized individuals from gaining access to pupils' private information.

During the trial, the researchers were only involved in the data collection activities; teachers took full responsibility for organizing and supervising the actual attendance supervision trial. Participating teachers volunteered for the trial, and it was their responsibility to adopt the attendance supervision system for everyday use in their class. The teachers explored new working practices introduced by the system and were expected to report their experiences and observations regarding the system.

The goal of the concept was to (1) enhance and secure children's independent mobility in home-school transition and (2) to increase the rationalization of home-school communication. The objectives of the field study were to test the attendance supervision system for school children and their parents and teachers, and to examine the value the attendance supervision concept brings to these stakeholders, as well as the attitudes of each user group concerning the use of the system (regarding e.g., privacy issues). The extent to which the service supports the enhancement of school routines and practices and improves information sharing between school and home was also examined in the study.

IV. USER EXPERIENCE DATA COLLECTION

Druin et al. [21] have argued that design work in a school is subject to difficulty due to the school setting and the embedded power relations between adults and children. Children have so few experiences in their lives where they can contribute their opinions and see that adults take them seriously [21]. When respect is fostered, it changes how children see themselves [24]. Williams et al. [22] implemented an exploratory workshop with ten 11-12 year old children for exploring and developing the interface between children and new mobile 'wearable' ICTs, and found that the children are valuable, adaptive and creative users in the participative design of ubiquitous computing experiences and devices that might enable them.

Druin [23] has developed a typology of roles that children may have in the design of new technologies: a user, a tester, an informant and a design partner. For each role she also presents three underlying dimensions: the relationship to adults, the relationship to the technology and the goals for inquiry. The role we sought from the children was essentially that of an informant. As the trial objective was concerned with the potential of the attendance supervision system, the actual usage of the technology was an essential prerequisite

to the children's articulation of potential use and for the informant role as well. Therefore in the case of this trial the children's role was both that of a user and an informant.

TABLE I. SUMMARY OF DATA COLLECTION METHODS AND NUMBER OF VALID CASES FOR EACH METHOD

Data collection method	Number of valid cases
First classroom observation and interviews with first grade class	16 pupils 1 teacher
Second classroom observation and interviews with first grade class	16 pupils 1 teacher
Classroom observation and interviews with special-needs class	7 pupils 1 teacher 1 special needs assistant
Phone interviews with the parents of the special-needs class	6 parents
Paper questionnaires for 16 first-graders' parents whose children participated in the trial	14 parents
Paper questionnaires for three first-graders' parents whose children did not participate in the trial	3 parents

Given difficulties that need to be overcome for describing and understanding user experience, we decided to collect data during the actual use of the system and to combine a variety of complementary data collection methods [19] in order to increase the reliability and validity of the results [20]. The user experience data collection methods and the number of stakeholders for each method are listed in Table 1. In the next sections we will present the data collection methods in greater detail.

A. Classroom Observations

Classroom observations were made to collect information about how the pupils learned to use NFC technology, what kind of routines they had established after using the system for some time, and what kind of spontaneous reactions and discussion took place in using the attendance supervision system. Children in the first grade class were observed twice over the course of the research. The first visit happened in a very early phase of the trial: the attendance supervision system had been taken into use only a day before the visit. At the time of the second observation the attendance supervision system had been in use for two weeks. The special-needs class was observed when they had used the attendance supervision system for two weeks. Observations with both classes were conducted during a normal school day by attending the first lesson in the morning. The login process was observed from the back of the classroom to minimize the disturbance caused by the researchers' presence. During the observation the children's behavior and actions were videotaped and photographed. The children seemed not to be disturbed or bothered about the researchers' presence.

B. Interviews with Children and Teachers

All the children participating in the trial as well as their teachers were interviewed in order to investigate their thoughts and experiences about the technology and service concept under evaluation. The interviews took place on the

same days as the classroom observations. After login was done and children started their school work, interviews were conducted very informally by chatting with a few pupils at a time either in the classroom or in a separate place. Children in the first grade class were interviewed twice over the course of the research. The teachers were interviewed informally partly in the midst of teaching, partly during breaks between classes.

The following aspects related to the attendance supervision were discussed with the children and the teachers:

- Where the children keep their "Robo" cards
- Do the children remember to bring the card with them every morning to school
- Have the children somehow personalized their cards
- How the children understand the technical details and functionality of the attendance supervision system
- How the children understand the reason behind the use of the system: why do they need to log in and out of the school
- Do the children think that their privacy is violated; that they are being stalked
- Do the children remember to log in when arriving to school and respectively log out when leaving school: does the teacher need to remind them
- How the children manage to use the smart card
- What is the children's general attitude towards the service
- Do the children know if their parents actively follow their attendance information via the system

The children seemed to be proud and excited that adults outside their school had come to their class just to chat with them and ask about their thoughts. The children were very happy with answering the questions and spoke freely and frankly about their own thoughts and opinions.

C. Phone Interviews with Parents

Since it is feasible to conduct one-to-one interviews with a small user group, the parents of six (out of seven) participating children (two fathers and four mothers) in the special-needs class were chosen to be interviewed via telephone. The parents of one child did not give their contact information for the interview. Interviews lasted from fifteen minutes to half an hour. In order to gain real hands-on experiences by the parents, interviews were conducted one and half months after the beginning of the field study when the parents had had time to experiment for a longer period of time with the attendance supervision system. The aim of the phone interviews was to investigate parents' thoughts on the service concept, opinions about possible added value the attendance supervision service brings to the families, and whether the service could be developed further to have a positive impact on their lives.

D. Feedback Questionnaires for Parents

As the parents of the first grade class formed a bigger user group and interviewing them via telephone would have been more cumbersome, we decided to create two separate short paper questionnaires, one for the first-graders' parents whose children participated in the trial and the other for the parents who chose not to allow their children to participate in the trial. Questionnaires were delivered to the parents one and half months after the beginning of the trial in order to assure that the parents had already gained real experiences with the attendance supervision system. A total of 17 parents (out of 19) answered the questionnaire. The same things were explored in the questionnaires as in the phone interviews (see Table 2).

TABLE II. QUESTIONS ASKED IN PHONE INTERVIEWS AND FEEDBACK QUESTIONNAIRES

	Question
Phone interviews with the parents of special-needs class children and questionnaires for participating first-graders' parents	Have you experienced the attendance supervision service as useful? What kind of benefits have you derived from the service?
	If in your opinion the service has not benefited you enough or it would still need more improvement, please tell us your suggestions for service development and improvement.
	Would you be ready to pay 30EUR a year for the SMS service?
	Have you experienced any problems with the service? If you have, what kind of problems?
	By your own estimate, how often have you used the service, i.e. followed your child's logins? (daily, weekly, not so often)
	Do you use the service in some specific situations? If so, in what kind of situations?
	In your opinion, how has your child experienced the attendance supervision and how has she/he remembered to carry the 'Robo' card with her/him?
	In your opinion, has the supervision system had any influence on your family's daily routines?
	Other ideas and thoughts regarding the service
Feedback questionnaires for non-participating first-graders' parents	Could you explain what factors had an influence on deciding not to participate in the attendance supervision experiment?
	If in your opinion the service in its current form would not benefit you enough or it would still need more improvement, please tell us your suggestions for the service development and improvement.
	Other ideas and thoughts regarding the service.

V. IMPACT FOR THE SYSTEM DESIGN PROCESS

We evaluated the obtained research data from the point of view of how various aspects identified in relation to this study affect the design processes of home-school interaction systems. We present in the following sections experiences and analysis from these findings. Some of these results have been presented earlier in [1] and [2].

A. Participation

Children, teachers and parents were able to participate in the system design process as well as the adoption process,

and we analyzed our data from the viewpoint of each user group:

1) Participation of Children: Three kinds of participatory aspects were identified: (1) Children were able to participate in the visual design of the smart card used for attendance control, (2) children participated in daily use by operating the reader devices and being responsible for logging in and out of school, and (3) children were able to express their opinions throughout the research process through various data collection methods.

Before the beginning of the field trial, one of the pupils in the special-needs class had invented the name "Robo" for the contactless smart card. His idea was used in designing the visual outlook of the card (see Figure 3). Receiving the card had been especially important for the boy who came up with the "Robo" name: the boy had been very pleased that his own idea had been implemented. According to the teacher, for the same boy the start of the school had been especially difficult and for him the opportunity to influence the smart card design had been a very important boost to his self-esteem. Even though the children's role in designing the card was not very big, the other children clearly valued as well that one of them was behind the idea for the smart card name and appearance.

Figure 3. The visual outlook of the "Robo" card and the reader device.

The teacher of the first grade class had shown and taught two pupils how to operate the reader device and what to do when the pupils needed to log out of school at the end of the school day (how to turn the device on etc.) when the teacher was not present. Every Wednesday, operating the reader device was their responsibility. This was also valued by the children, as they saw this as a sign of trust in their skills, and a source of special pride for the whole class, not just for those two children in question. Other children commented on this by saying that, *"…they were chosen because they use the computer also for other things than just playing,"* so the two pupils were regarded to be knowledgeable and skilled in the use of computers.

Interaction systems for children are usually designed by adults who often have very little idea of children's needs and desires [29]. Several authors [24, 29] have identified that

involving children in product development is beneficial. Our findings revealed that children valued that they were able to participate and be active in the design, use and evaluation processes. By participating, they could have their voices heard and influence the decisions that affected their school days. Also, our experiences indicate that by participating in the design and use processes the children became aware and internalized the functionalities and goals of the system, which can lower the barriers for adoption and use.

2) Participation of Teachers: Participation of teachers was seen to be especially valuable in integrating the application and processes into the daily routines of a school day. The teachers took the responsibility of integrating and supervising the adoption of the new practice. Our experiences indicate that this is essential for the success of adoption.

The teachers were able to observe the use and the user experiences evoked in the children daily. This knowledge was very valuable for interpreting the data collected by interviews and observations.

3) Participation of Parents: Parents gave many ideas for the system development and improvement in the phone interviews and questionnaires, and they were identified as important partners for the design and evaluation processes, which is also supported by previous studies [3].

Parents reported that following the children's logins and logouts was not very practical and did not integrate well with their daily routines. Parents needed to separately log in to an online 'citizen's portal' and that took way too much time during a busy workday, in their opinion. The information of children's logins and logouts should be received on the device that is nearly always at hand. Therefore, the text-message service appeared to be a more usable solution in monitoring children's attendance: *"We do not always have an opportunity to be by the computer, so a message to a mobile phone would bring lots of additional value."*

One parent stated that she would preferably receive the attendance data in an email, while another parent did the majority of his work on a PC so he was able to follow his child's attendance information regularly during his work days. He found the text-message service more harmful than useful because a parent could *"be bombarded with text-messages"* during the work days, which could disturb and interrupt working.

In the parents' opinion it would be much better if the children could log in to school immediately when they arrive on the school grounds, for example at the school gate or by the school's front door, as opposed to the login done inside the classroom. Then the parents could get the attendance information as soon as the child arrives to the school area. One parent reported that for their family it would be much more useful to get a message indicating whether or not their child has locked the front door when leaving for school. A desire was expressed that it were possible to send a message from home when the child leaves for school and the device would then react if the child does not log in to school within a time limitation. Also, a child's timetable could be added in the system and a message could be sent to parents if the child did not arrive at school in time.

Several parents mentioned that they hoped to see the attendance supervision service developed further to include more features. For example, in one parent's opinion the paper notebook for home-school communication was already outdated and behind the times, so a web-based counterpart would be much better. An idea was raised that more services could be added to the card (the card functioning also as a library card, for example) as well as important daily information about school. That information could also be checked from the web portal. Parents also stated that they would like to be able to see longer-term statistics about their child's logins and logouts instead of only day-specific data.

B.   Adoption and Use

At the time of the first visit to the first grade class, a routine for the login had not yet had time to develop and the login had not yet been integrated into the children's everyday school routines. As the pupils arrived to the classroom, the teacher had to remind most of them about the login. The children had quite different ways of doing the login procedure; some merely touched the reader device with their card while some carefully placed the card on an exact position on top of the device.

Using the system seemed to be easy according to the children: *"You just put the card there like this," "You can put it either way," "You don't need to wave it, just flash it there quickly," "When it [the device] says OK, login has succeeded."* In Figure 4 there are pupils logging into the school.

Figure 4.   Pupils log into the school by touching the reader device with their contactless smart cards.

All the pupils had already allocated some specific place for their card where they always put the card so that it remained safe. Most of the pupils said they kept their cards in their backpacks, and many even had one particular pocket in the bag where they put their cards. Some pupils said that they kept their card in a pen case.

The pupils seemed to remember well to carry the card with them every day, with only a few exceptions. One child said that her Mom took care that the card is with her by putting it into her bag in the morning. On the first observation day one boy had not brought the card with him to school since, *"the card is on the table at home, Mom did not remember to put it with me."*

At the time of the second observation, the attendance supervision system had been in use for two weeks and the login had now become a natural part of the children's school routines. As the children arrived in a classroom, they remembered without a separate notification to take their cards from their backpacks and to log into school. According to the teacher a small line usually emerged behind the reader device and then the latest children remembered the login.

The teacher of the special-needs class said that before the experiment had started pupils had eagerly been asking, *"When do we get the cards? When will the device arrive?"* Similar to the first grade class, the login process appeared to have integrated well in to the school routines after only two weeks use. The teacher did not need to separately remind the children to log in as the children remembered it themselves. The login happened by touching the card with the NFC phone.

In the special-needs class the login seemed to happen quite smoothly, only with some slight bustling and elbowing: *"It's my turn now!" "Wait for your turn!"* Similar to the first-graders, all the pupils said they kept their cards in their backpacks, and most had one specific pocket in their bag in which they always put their card after login.

The classroom observations revealed that the login with the smart card reader device was faster when compared to the NFC phone as children did not need to queue for the reader device. In addition, with the reader device, the children practically did not need the teacher at all for the login. They were able to handle it independently instead, contrary to the login done with the NFC phone. According to the first-graders, login with the reader device at the classroom was easier than login with NFC phone in the day care: *"The cell phone needs to be moved back and forth in a way," "It takes more time."* the children explained. Also the teacher of the first grade class said: *"It worked like an assembly line,"* with the reader device.

The teachers said that the children had been extremely excited when they had heard they could participate in the experiment. The pupils had waited intently to receive their own cards, and after a few weeks' use had only positive thoughts about the attendance supervision: *"This is easy to use, login has worked well."* Teachers reported that the children had easily learned how to use the card, and the login had soon become an integral part of their school day.

C.   Children's Understanding of the Whys and Wherefores

The first-graders' seemed to understand pretty well why they had received their "Robo" cards and what the purpose behind the use of the attendance supervision system was, which is shown in the following excerpts gained from first-graders' interviews: *"Mom and Dad will know that I have arrived at school and at home." "The reason for doing the login in the morning is that the thing starts to transmit information to somewhere, and in the afternoon when leaving school you need to log out so that the thing won't*

send any more information and so that the information would not proceed anymore."

The first-graders also had noticed some benefits the attendance supervision system had brought to their lives: *"It's also nice that you don't need to phone when you have arrived at school." "Once when I came to school by bike and Mom tried to call me, my Mom had put my phone in that kind of place in my backpack where I couldn't find it. At that time we did not have this card thing yet, but it's good that we have it now."*

Children in the special-needs class understood also the reason behind the use of the system, and seemed to understand how the system created value for parents and school. However, it is possible that the children's answers partly repeated the same words the teacher and their parents had told them about the attendance monitoring: *"Mom and Dad know at what time you have arrived at school and left home, and if you have stayed in detention." "You need this at your new school, so that they know whether you are late or not." "You do the login because you need to touch the phone." "Parents check at their work place that you have arrived at school."*

When the children were asked whether they knew if their parents had been checking their attendance information, about half of the pupils were aware that their parents had been monitoring their attendance information: *"My parent watches the logins through the Internet." "Mom said that she hasn't checked yet." "Mom sometimes looks, but not every day." "Mom does not check the logins until at home in the evening."*

D. Children's Understanding of the Technology

Children of the first grade class did not really understand the technical details behind the system, and they did not seem to have thought about it that much. When we asked them what they thought about how the system worked they were rather baffled at first and then some of them were able to give us answers: *"It puts the information on the computer.", "There is some little thing in the cell phone, a kind of strange looking tiny card inside the phone, a plastic one with nothing inside, which takes the information.", "I wonder what does my Mom see? Does some explanation mark like appear, that your son has left home from the day care, that it is a safe journey?" "The cell phone is a bit like a living thing, it reads that information and then it happens."*

Specifics of the technical details and operation of the system were not very clear for the special-needs class children either, even though they had a reasonable understanding about how the technical components involved together and some basic conception of how the system functions: *"It writes names on the Internet, are you at school or where?" "It sends an e-mail or a message and Dad opens his phone and sees a text message." "A message leaves when the card and the phone touch." "A light appears in the machine telling that you are late. Green flashes when you have arrived at the right time."*

E. Attitudes towards Privacy

When planning and designing the system for children's attendance supervision we were aware of the potential of such technology to increase the debate on the issue of surveillance and privacy invasion. Concerns were expressed even before the actual system was taken into use when the Finnish media published the plans for implementing and testing the NFC-enabled school attendance supervision concept in the city of Oulu. On the web site of the local newspaper many readers expressed their biases and opinions about the system. The following excerpts are from the discussion on the web site (translated from Finnish): *"For real, big brother will also monitor in this case [27]." "Personally, I would certainly not accept stalking through access control at our school, the old, traditional control of non-attendance made by the teacher is enough...we need to really take care that the high technology of the future will be used to help people, not to stalk them [27]." "The next phase is a microchip planted on the back of the hand, the mark of the beast from the Apocalypse of John...[26]"*

However, during the study itself the privacy concerns and negative aspects of surveillance did not play a big role, contrary to the previous studies [3, 5, 10]. The benefits of monitoring were seen as greater than the costs by all the interest groups. For example, one parent stated in the phone interview that in her opinion it is good that you can monitor your children, since, *"...life is changing all the time, it is becoming more fierce."* One family reported that because of the attendance supervision system, they did not need to provide their child with a mobile phone which they would have otherwise done to monitor how the child travels between home and school.

In their interviews, children themselves did not bring up any comments regarding stalking, losing their privacy or being under surveillance. Quite to the contrary, and also according to the parents, the children regarded the attendance supervision as a natural part of the school routines, and did not wonder why they were given the cards and why they had to do the login every day, because, as one of the parents said: *"For a child it is just part of his life."*

NFC technology is a very short-distance technology requiring a close touch to activate reading. Based on our observations, we expect that this increases the feeling of control, and does not trigger the feeling of being under surveillance. Other types of RFID technologies that can be read automatically from a distance without any explicit action from the user side can create a stronger feeling of being under surveillance by "an invisible eye", therefore triggering negative experiences towards the loss of privacy and being monitored. This has become very apparent in earlier surveillance initiatives conducted in school environments [6, 7, 8].

The contactless smart cards used in our study contained only an ID number, not any personal information (other than the printed name on the card surface), pupils' online attendance data was put under password protection and text-messages were sent only to authenticated mobile phone

numbers, and so unauthorized individuals were prevented from gaining access to pupils' private information.

F. Trust and Respect

The parents reported that the contactless smart cards and the attendance supervision concept had been received very well by the children. Parents said that their children felt the supervision was important and took a big responsibility for keeping the card safe and carrying it to school every day. One of the parents commented, *"A proud and eager pupil has remembered it well."* For example, one child had gotten really excited when he received the card that was similar to the card his father used at work. The parents said that the children had taken care that they always had their cards with them, and for some of them it seemed to be very important that they had their cards with them all the time. Figure 5 shows some pupils logging into school.

Figure 5. Pupils log in by touching the teacher's NFC-enabled mobile phone with their "Robo" cards.

For many children the possibility to participate in this trial seemed to be a boost for their self-esteem, which is also consistent with previous research [25]. The children were very proud and excited that they were shown trust by giving them their very own contactless smart cards that were their own responsibility, and that adults trusted the children to take care of the cards and the login. This is well illustrated in the following teacher's comment: *"For the children this has been an important and big thing, since not all the classes have these cards in use, so in that way children now have a chance to stand out and they have something that others do not have."*

We had expected that the children would have taken some actions to personalize their cards but the interviews and observations revealed that children had not modified their cards' outlooks in any ways. It seemed that the children placed a high value on the card and showed respect by not modifying the card. The children seemed to appreciate their cards so much that they did not even think of the possibility of e.g. adding any stickers or drawing on them. One girl commented that, *"I wouldn't dare to put a sticker on without asking."* The children also seemed to have developed some misconceptions about the system, which can be partly interpreted as an outcome of the fact that they had not internalized the technical details and functionality of the system: *"When there is a sticker on the card and you log in, the cell phone accidentally takes the sticker and some picture of Winnie the Pooh or something appears there,"* one child said.

However, many of the pupils knew that secondary school students had received NFC mobile phones for attendance supervision and the pupils seemed to be a bit jealous about it. One of the children said, *"Smart cards could have been given to the secondary school students and we could have had the touch mobile phones."* Clearly, mobile phones were valued as devices and status symbols more than smart cards.

The children evidently valued the trust they were given, but they also used this new power to mutiny against teachers and parents. One child had thrown his card away in a burst of anger towards his parents. In general, however, children accepted parents' and teachers' authority in protecting them [30] through attendance control without question. The children could have chosen not to mark their arrival to and/or departure from school as a sign of rebellion, or could have given their card to a classmate to handle the login and logout on their behalf. However, this type of behavior to manipulate the system did not come out in our trial group. We assume that this might be different with older children and teenagers.

G. Adults' World

On the web site of the local newspaper many readers commented on the attendance supervision system also in the following way (translated from Finnish): *"A child is not allowed to grow up at her own pace anymore; she will be raised in a real 'Orwellian' spirit [27],"* *"Here the monitoring, caring and presence of a grown-up is trying to be replaced with a ridiculous mobile phone [27]."*

The children themselves did not wonder why they had to do the login and did not resist new practices; they simply regarded it as a natural part of school routines. This is well illustrated in the following excerpt from one of the teachers: *"Nowadays children have seen so many kinds of things that they don't marvel at things like this."* The children had only positive thoughts about the attendance supervision, it had been *"nice"* and *"easy,"* even *"awfully nice, giant-sized!"* and *"really great!"*

However, those parents, whose children did not participate in the field study, explained that they had considered that, *"The safety of the child is created through the genuine presence of an adult and not through a supervision system."* These parents thought that what children really need is the time of trusted adults, and also considered the trial to be a technology-led project *"Where the effect of the project on a child's everyday life had hardly been thoroughly considered,"* which is also argued in previous research [9, 10]. Parents stated: *"Children of this age should not need to be rushed into the world of cards and codes. They can do that later. The amount of new things in the first-graders' world is already large enough."*

H. Responsibilities

The teachers said that the parents had expressed their interest towards the system for practical reasons; to be able

to know where their children were. It often happened that a child had forgotten to phone Mom or Dad, and consequently the parent made a 'check call' to the teacher in order to make sure that the child had safely made his/her way to school. For example, one child had once promised to call his father as soon as he arrives at school but the batteries had died out from his cell phone so he was not able to make the promised call. So, the attendance supervision system facilitated the teacher's work by eliminating the need for a teacher to answer parents' calls during the school day.

However, some parents chose not to participate in the trial, as they thought that the teacher should have full responsibility over the whereabouts of the children, and felt that a computerized system would remove this responsibility from the teachers. One of the parents said, "*If parents cannot trust that the teacher knows where the children are (ill, at school, on vacation etc.) something is really wrong.*" One parent argued that in the case that a child does not arrive at school and there has not been any notice about the absence, it is teacher's duty to contact the parents, so, "*What kind of additional value does the service bring to parents?*"

In addition, the parents commented that the system can sometimes cause extra worry, as the child might lose the card or forget to log in upon arrival: "*The login is based on memory, so parents cannot be sure that the child is at school if the child has forgotten to log in or if the child has lost his card.*"

In one parent's opinion all the resources should be directed to preventive work in regard to safety, such as traffic, school environment and social support: "*What does it help to get the information that something has happened, if something could have been done to prevent that from happening!*"

I. Added Value

About half of the parents who participated in the trial answered in phone interviews and feedback questionnaires that they were satisfied with the system and thought that the system adds value for them. The system was seen as especially useful when both the parents are working and are able to follow through the system that their child has arrived at school and check at what time the child has left for home. The system was also found valuable in that it would notify the parents immediately in situations where the child for some reason does not arrive at school or in day care.

However, the interviews and questionnaires revealed a fact that for some families the attendance supervision system did not bring real added value. In these families one of the parents was always at home when the child left for and arrived from school, enabling the parent to follow the child's comings and goings, or a family lived so near the school that the child had only a short way to school.

Some parents also thought that the service only brings the same feeling of safety as calling with a cell phone when ensuring the child's arrival at school, so the system does not bring real value when compared to an already established practice. In one parent's opinion the attendance supervision for older pupils would bring more benefits, since she

considered that a small pupil is already quite well controlled by the school and day care.

One interesting finding was related to situations where the parents were separated. The system could provide a parent not living with the child (at the moment) with a way to know more about the daily activities of the child. This could provide a better feeling of involvement in the life of a child. In our trial, one father not living with her daughter would have liked her to participate in the trial so that he could get more information about his child, but the mother who lived with the child refused the child's participation.

J. Downsides

Most parents wondered why their child's login always happened so late in the morning, for example the child might have left home to go to school at 7:30 am, but the login however, did not happen until around 8:30 am. As the parents knew that the journey to school should not take this long, it easily caused concern and worry. The delay was caused because the reader devices were located in the classrooms, and some mornings it took some time before the children got inside or remembered to log in. In the parents' opinion it would be much better if the children could log into school immediately when they arrive on the school grounds, for example at the school gate or by the school's front door, as opposed to the login done inside the classroom. Then the parents could get the attendance information as soon as the child arrives on school grounds.

A few parents also expressed concerns about increasing the amount of information they needed to follow: "*In this insecure world it is good to know where the child is, but the information flood and reading of messages is already now fully employing the parents and therefore it feels that the 'traditional' way should be enough. But naturally, if there is a fear that the child is skipping classes or thinks of leaving on his/her own way from school, the attendance supervision service is good.*"

In the first grade class three children did not participate in the trial. The parents of those children justified their decision by saying that the attendance supervision system could cause parents extra worry instead of increasing the feeling of safety and peace of mind, as the child might lose the card or forget to log into or log out of school.

K. Economic Feasibility

The administrative units of the city of Oulu estimated that if the system with the SMS notification service were adopted at schools for permanent use, it would cost each family using the system approximately 30 EUR per year. Parents' willingness to pay the suggested amount of money for the service was inquired in the phone interviews and feedback questionnaires.

Altogether 11 parents who participated in the trial stated in phone interviews and feedback questionnaires that they would be ready to pay the suggested amount of 30 EUR per year for the SMS service: "*I could also pay for security.*" Five parents said that they were not willing to pay for the service, one parent wasn't sure, and three did not give their answer to the question.

The expenses of the system would include at least hardware and software costs for the backend system and the hardware units (smart card reader devices and NFC-enabled mobile phones) needed in schools, data transfer costs between the backend system and the reader devices, contactless smart cards for the pupils, the price of sending SMSs to parents, deployment costs, and the maintenance costs of the system. However, teachers would need less time for administrative work and could use that time for teaching instead. Parents would also save time since they would not need to make check calls to their children. In this context the time savings is difficult to convert into direct financial savings. Rather, here the time savings means for the teachers the prospect of increasing the quality of education and for the parents the possibility to concentrate better on their work when they do not need to worry for their children's safety.

However, there is a possibility that this kind of fee-based attendance supervision service creates inequality among the pupils, as not all the parents would be willing to pay for the service. The quite low percentage of parents ready to pay for the service (55%) in this study might be partly explained by the fact that Finnish people are accustomed to thinking that school attendance is free and therefore they do not easily, maybe just out of principle, accept the idea that a purely school-related service would be subject to a charge. Also, in a situation where only some of the families were using the attendance supervision service provided by the authorities the teachers would in any case need to also do the manual roll calls thus reducing the time savings for teachers and possibly even causing extra work for them.

In Finland the school system is based on public schools, and basic education is free for citizens. Therefore, public authorities play an important role in adopting new technologies in the school environment. This means that investments are covered with public funding and decisions for adopting new technologies are done through public decision making processes. In the case of public services, goals and criteria for adopting may differ significantly from the private business environment, where the goals usually deal with maximizing profits and can be justified with economic reasons. With public services it can be difficult or meaningless to show the created value only through economic measures.

Evaluating the value of adopting new technology in an environment that is fully financed by public authorities and serves various user groups with different needs is challenging. It would be possible to calculate the actual costs of deployment and continual use of the attendance supervision system in order to make an educated decision on whether or not it is economically feasible to take the system into use. However, the schools do not operate in a business environment, trying to generate revenues and operate at minimum cost level. Instead, schools create value for the society and the families using their services. Benefits of adopting new technology in such a setting must include other value parameters in addition to traditional cost or time savings.

VI. CONCLUSIONS

In our trial, information about user experience was obtained by combining different data collection methods. The findings were analyzed from the viewpoint of three end-user groups, namely, children, parents and teachers.

The attendance supervision system can reduce unnecessary doubt by allowing parents to receive real-time information on non-attendance or if a pupil is late from school. The main benefits for the home are that parents can follow their children's attendance status in school and day care in real time, thus eliminating the need for calling the child or the teacher to inquire about the child's whereabouts. The service also facilitates teachers' work by offering technology and a system for gathering the information about children's attendance and keeping a log about their possible tardiness at school.

The importance of the role of children in the research process was emphasized throughout the research project to overcome the problems associated with children as research subjects [21]. The children were respected as users of new technology and their contributions and ideas were sought out and valued. All communication was planned to convey a message that the children could trust that adults will listen to their thoughts and ideas, and respectively the adults aspired to learn to elaborate on the children's ideas, rather than merely listen passively or not listen at all [24].

For many children the possibility to participate in this trial was a boost to their self-esteem. The children were very proud and excited that they were shown trust by the adults by giving them their very own contactless smart cards that were their own responsibility and that adults trusted them to take care of. Also, the children valued the responsibility they were given for logging in and out of school and even operating the reader devices by themselves. Similar results have also been discovered in research by Attewell [25].

User research revealed that for the children at this age as well as for their parents, the concept of being monitored by the technology is not something they reject, but possibly welcome. Interviews and questionnaires with parents and children revealed that mobile phone ownership among this age group is closely tied to parental purchases, and motivated by parental and child desires for parents to be able to contact their children when they have to go to school alone. With this new attendance supervision system children would be able to go to school alone even if they did not have their own mobile phone, since the attendance monitoring would enable parents to check that their children had arrived at school safely, thus making check calls between parents and their children (or between parents and teachers) unnecessary.

Main concerns with the attendance supervision system relate to privacy and security issues concerning the collection of pupils' real-time attendance details and the possibility that unauthorized individuals could gain access to children's movements and location and personal data. In this study privacy concerns were not raised, which seems unique when compared to previous research [3, 5, 10]. We expect that one reason for this is the nature of the NFC technology, which enables reading the ID only upon touch.

It also needs to be noted that security at school is improved via an attendance supervision system: it is easy to see which pupils are in which classrooms. Real-time attendance logs are also important for a pupil and for his or her legal protection.

A. *Implications for practice*

This study has some concrete implications for practice and research related to technology adoption in a school setting. First, our findings revealed that children valued that they were able to participate and be active in the design, use and evaluation processes. By participating, they could have their voices heard and influence the decisions that affected their school days. Also, our experiences indicate that by participating in the design and use processes the children became aware and internalized the functionalities and goals of the system, which can lower the barriers for adoption and use. In addition, the fact that the teachers took the responsibility of integrating and supervising the adoption of the new practice appears to be essential to the success of adoption.

Also, the children, as well as their teachers, became familiar with the login process very quickly, and the attendance supervision was soon integrated into their everyday school routines, mainly due to the intuitiveness and effortlessness of the NFC touch-based interaction technique [17][18]. However, the interviews showed that the children did not fully understand the technical details or functionality of the attendance supervision system even though they seemed to have a good comprehension of the reasons behind the use of the system, and they knew how the system created value for their parents. For the children to get full value of the technology it is important to give them enough information about the system and how it works.

Comments by the parents clearly showed that when a new technology is brought into a school environment, it needs to be clear for everyone how the adoption of the system affects the responsibilities of school personnel, parents and children. In this case, the responsibilities of the teacher remained the same, and the technology was used only to support and enhance communication. However, many parents felt that the technology would remove responsibilities from the teachers.

If this kind of system were taken into wider use economic feasibility of the system needs to be considered. 55% of the participating parents in this study were willing to pay a small amount of money per year for the use of the system. It is likely that not all the expenses would be covered by the money received from the parents, which means that the rest of the expenses need to be paid using tax money. A fee-based attendance supervision service might also create inequality among the families, as not all the parents would be willing to pay for the service. We think that this is part of the bigger discussion of using tax money to pay for some services versus citizens paying for the services partly themselves in addition to paying taxes.

Even though the children themselves did not get direct benefit from using the system, they valued the fact that they could actively help teachers and parents by creating useful and valuable information. Perhaps surprisingly, the children seemed to be the group most pleased with the system. When describing their experiences with the system, the children's descriptions were positive and enthusiastic. Our analysis shows that a technology supported attendance supervision system can bring value for all end-user groups but it seems that the system will, however, primarily serve the teachers and the parents.

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