A Review of Research Methods in Children's Technology Design

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ABSTRACT
Research methods have been objects of discussions for decades and defining research methods is still a quite considerable challenge. However, it is important to understand research methods in different disciplines as it informs us on future directions and influences on the discipline.

We conduct a survey of research methods in paper publications. 105 papers on children's technology design are classified on a two-dimensional matrix on research method and purpose. Our results show a strong focus on engineering of products as applied research and on evaluation of developed products in the field or in the lab. Also, we find that much research is conducted in natural setting environments with strong focus on field studies.

Keywords
Research methods, children's technologies, HCI

INTRODUCTION
Design of children's technologies has received increased attention during the last years [1]. Children encounter and use software technologies in their daily lives, e.g. cellular phones to communicate, computer games for individual or collaborative entertainment, or educational technologies for learning. Children are currently emerging as a rather frequent and experienced user population [2].

Experiences gained in research projects have illustrated opportunities and limitations associated the design of children's technologies and the involvement of children in the design process. Different research methods have been adapted in research projects involving children. This is no different than other disciplines, but it is important to understand how research methods have been adapted in different disciplines as it potentially informs us on future directions and influences on the discipline [4].

Inspired by studies within information systems and related disciplines, we wish to evoke the discussion of research methods adapted in children's technology design. Research methodology has been examined in information systems for years (see [3, 5, 8]). A number of frameworks have been proposed to facilitate the discussion of research methods in information systems. For the study in this paper, we find the classification scheme found in Wynekoop and Congor, cf. [8], useful as it provides a simple but powerful analysis of a research discipline.

We wish to provide a snapshot of current and previous research conducted within our discipline to highlight how the research has been carried out. Thus, our aim is also to provide a mechanism that can be used to further develop a community of researchers with interaction design and children, which is likely as important to a young discipline as ours. Section two outlines and describes the classification matrix explaining different research methods and purposes. Section three classifies research methods in papers on children's technology design (the papers are listed in the appendix). Section four discusses the results of the study and compares the results to studies of other disciplines.

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RESEARCH METHODS AND PURPOSES
Research methods have been objects of discussions for decades and defining research methods is still a quite substantial challenge [4]. Since the aim of this paper is to classify existing research papers according to applied research methods in the design of children's technologies, it is not our intention to define research methods or propose new research methods. As a result, we have chosen a definition found in Wynekoop and Congor [8] for classification of research methods in computer aided software engineering (CASE) and later adapted by Kjeldskov and Graham [4] for mobile human-computer interaction research methods.

This classification of research methods proposes a matrix of two dimensions namely research methods and research purposes. In the following, we will provide a very short description of the research methods and purposes extracted from the discussions in [4, 8], supplemented by definitions and discussions of research methods in information systems [6, 7, 9] (for more detailed descriptions please refer to [8, pp. 132-141; 4, pp. 318-324]. The eight research methods include case studies, field studies, action research, lab experiments, survey research, applied research, basic research, and normative writings. The first three are natural

	Method	Strengths	Weaknesses	Use
Natural setting	Case studies	Natural settings Rich data	Time demanding Limited generalizability	Descriptions, explanations, developing hypothesis
	Fields studies	Natural Settings Replicable	Difficult data collection Unknown sample bias	Studying current practice Evaluating new practices
	Action research	First hand experience Applying theory to practice	Ethics, bias, time Unknown generalizability	Generate hypothesis/theory Testing theories/hypothesis
Artificial setting	Laboratory Experiments	Control of variables Replicable	Limited realism Unknown generalizability	Controlled experiments Theory/product testing
Environment Independent Setting	Survey research	Easy, low cost Can reduce sample bias	Context insensitive No variable manipulation	Collecting descriptive data from large samples
	Applied research	The goal is a product which may be evaluated	May need further design to make product general	Product development, testing hypothesis/concepts
	Basic research	No restrictions on solutions Solve new problems	Costly, time demanding May produce no solution	Theory building
	Normative writings	Insight into firsthand experience	Opinions may influence outcome	Descriptions of practice, building frameworks

Table 1. Summary of research methods on strengths, weaknesses, and use (adapted from Kjeldskov and Graham [4]).

setting research methods conducted in real organizational settings, the fourth is an artificial setting research method conducted, while the latter four are environment independent setting research methods as they assume no influence by the context.

Case studies are intensive evaluations of small samples of entities e.g. groups, organizations, individuals, systems, or tools [9]. Usually researchers will collect both quantitative and qualitative data through multiple means including interviews, observation, questionnaires etc. Often none or few experimental or statistical controls are enforced [3].

Field studies are research activities taking place in the real world. Field studies can integrate both quantitative and qualitative approaches ranging from ethnographic studies to field experiments. Ethnographic field studies typically bring the researcher in the field spending considerable time observing the environment, whereas field experiments are characterized by manipulation of independent variables to observe changes in a natural setting [3].

Action research reflects research where the researcher conducts the research activities while participating in the intervention and simultaneously evaluating the results [5]. Action research aims at both contributing to the practical concerns of people in problematic situations and to the goal of social science in a joint collaboration [6].

Lab experiments, opposed to field experiments, take place in a controlled environment with the experimenter in control of assignments of subjects, treatment variables, and manipulation of variables [7].

Survey research applies information from a known population gathered through e.g. interviews or questionnaires. The data is collected directly from the respondents and normally assumes unaffected by the context.

Applied research informs research where intuition, experience, deduction, and induction are used to analyze a specific research problem [8]. Typically, the approach taken in applied research to solution finding is trail and error based on the capabilities of the researcher.

Basic research is about developing new theories or performing research in a field where the problem is known, but the methods and solutions are not known. The approach is, like applied research, trail and error based on the capabilities of the researcher.

Normative writing is a final category of research methods included by Wynekoop and Congor which they refer to as "non-research" writings about phenomena of interests. They suggest that normative writings include concept development writings, presentation of "truth", and application descriptions [8]. Concept developments indicate direction for future research whereas presentations of "truth" present ideas of concepts that seem intuitively correct.

Wynekoop and Congor propose a second dimension in their matrix namely research purpose [8]. In our review of research methods in children's technology design, we will adapt the same dimension. The categories and definitions for the five research purposes are summarized below.

1) *Understand* is the focus on grasping the meaning of the entities being studied, e.g. frameworks that attempts to categorize for better understanding. 2) *Engineer* is the focus of research where the aim is to develop new systems or parts of systems. 3) *Re-engineer* is the re-development of an existing system or part of a system usually based on an evaluation. 4) *Evaluate* is the assessing or validation of a product or a system, either to compare a single product or to compare more products. 5) *Describe* is the research that defines or describes features of an ideal system or situation.

	Case studies	Field studies	Action research	Lab experiment	Survey research	Applied research	Basic research	Normative writings
Understand	2, 12, 31, 34, 48, 53	18, 20, 36, 39, 45, 52, 70, 86, 88		4, 17, 39, 82, 88, 101	56, 89			24
Engineer		14, 22, 23, 42, 61, 67, 93, 96	1, 2, 21, 22, 23, 44, 62, 68, 78			3, 11, 15, 16, 18, 27, 30, 32, 33, 47, 51, 57, 58, 63, 64, 65, 66, 71, 72, 73, 75, 76, 79, 81, 83, 84, 85, 87, 88, 89, 90, 91, 92, 94, 95, 96, 98, 99, 104, 105		
Re-engineer		49, 93	37, 38, 49			7, 15, 57, 71		
Evaluate		5, 6, 7, 9, 10, 11, 14, 16, 19, 20, 21, 27, 28, 30, 43, 46, 55, 57, 59, 60, 66, 67, 68, 69, 75, 76, 81, 84, 85, 87, 89, 94, 95, 96, 102, 104, 105		2, 3, 8, 13, 15, 32, 35, 37, 38, 40, 41, 47, 50, 54, 58, 62, 65, 66, 71, 72, 73, 74, 77, 79, 80, 82, 87, 88, 92, 97, 98, 99, 103				
Describe							4	25, 26, 29, 46, 59, 60, 61, 63, 81, 87, 95, 100

Table 2. Classification of research methods in children's technology design. The numbers refer to the items listed in the appendix of the reviewed research papers.

CLASSIFICATION OF RESEARCH METHODS IN CHILDREN'S TECHNOLOGY DESIGN

This section will present our review of research methods in selected research papers on design of children's technologies. This will be done accordingly to the definitions of the matrix by Wynekoop and Congor [8]. A total of 105 papers were selected from the following top-level journals and conference proceedings for the period 1996-2004:

- Transactions on Human-Computer Interaction, ACM
- International Journal of Human-Computer Studies, Elsevier
- International Journal of Human-Computer Interaction, LEA
- Behaviour and Information Technology, Tayler & Francis
- Interacting with Computers (IwC), Elsevier
- Personal and Ubiquitous Computing, Springer-Verlag
- Conference on Human Factors in Computing Systems, ACM
- Conference on Interaction Design and Children, ACM
- International Conference on Human-Computer Interaction, IFIP
- Symposium on Designing Interactive Systems, ACM

While other journals and conferences exist, we find that the pool of included research papers provides a solid base for our review given the number of papers and the high-quality reviewing process of the journals and conferences. The 105 papers were selected for the review based on a thorough examination of all full research publications in the above journals and proceedings. This was done by reading abstracts (and sometimes introductions etc.) of all publications between 1996 and 2004. A paper was selected for the review if it dealt with issues or aspects of children's technology design. Adapted from Kjeldskov and Graham [4], all selected papers were printed out, numbered, read through and we aimed to ensure consistency by scanning all papers a second time over a single day and to ensure validity by having both authors reading and classifying all 105 papers individually and then afterwards negotiate the classifications in a collaborative effort. The classification of the papers can be found in table 2. As with the survey by Kjeldskov and Graham, some of the papers clearly employed more than one research method and had multiple purposes. As a consequence, these papers were given multiple classifications and appear more than once in the table which in hand implies that aggregate percentages sometimes amount to more than 100%.

Table 2 shows that 53% of the selected papers fall into the field study category (56 of 105 papers). The second and third most used categories are applied research (42%) and

lab experiments (37%). We found 13 entries for normative writings, 12 for action research, six for case studies, two surveys, and one for basic research. Our study indicates no clear bias towards either natural setting environments, artificial setting environments, or independent setting environments, but there is a somewhat strong focus on natural setting environments.

Considering the research purpose, we find that 67% of the papers did some sort of evaluation (70 of 105 papers), of which 53% are conducted in field evaluations (37 of 70) and 47% are conducted in laboratory experiments (33 of 70). The second most preferred purpose is engineering with 54% of the papers (57 of 105 papers) of which 70% would employ applied research as research method (40 of 57). Also, 23% papers fall into the category of understanding mostly based on case studies, field studies, or lab experiments. Thus, there seems to be a clear bias towards evaluating products (often with children at different ages, but also different kinds of adults, e.g. teachers) and on developing (engineering) prototypes and products for children.

Of the 44 papers on applied research, 91% would do so for engineering purposes while 9% would re-engineer. Considering the 40 papers employing applied research for engineering purposes, we found that 40% of these papers followed up on their design with a field evaluation and another 40% followed up with a laboratory evaluation (one paper conducted both a field and a lab evaluation). Hence, 9 of the 40 papers (23%) did not report any evaluations of the engineered solution. Furthermore and quite remarkably, only two of the 40 papers report activities on understanding (both papers are journal publications). Thus, 95% did not report any findings related to understanding.

Many of the papers involve research in natural setting environments with 70% (74 of 105 papers). Much of this research takes place in field studies 76% (56 of 74), but also as action research with engineering purposes 12% (9 of 74). Furthermore, of the 24 papers aiming to understand, most would conduct research in a natural setting environment (63%). This would usually be done be observing children in their natural habitat, e.g. schools. On the other hand, 25% of the understanding papers would employ a lab-based setup (6 of 24 papers). Finally, of the 13 papers in the description category, 12 would fall into the normative writing category proposing ideas and suggestions of e.g. methods for developing with children.

DISCUSSION

Our study reveals that much research on design of children's technologies focus on evaluating or engineering purposes and many papers present some design solution typically followed by a controlled, systematic evaluation with the purpose of assessing the success of the engineered solution. On the other hand, there is no clear bias towards any preferred environment for research conduction on children's technology design, but natural setting environments are commonly used. Such research is typically conducted in schools primarily for evaluating educational products. Examining the results of our survey further, we identify a number of interesting issues that seem to characterize the field of interaction design of children's technologies.

First, our discipline has a strong focus on natural setting environments. This is pursued primarily through different kinds of field studies and secondarily through action research and case studies. The strong focus on natural settings and field studies is in deep contrast to the survey study on mobile technologies [4]. Kjeldskov and Graham found that very few studies on mobile technologies moved into a real world context for any research purpose. One identified problem was the lack of control in a real world setting, e.g. when evaluating a product in the field it could be difficult to judge influence of contextual factors when assessing the mobile system. However, this lack of control does not seem to influence the evaluation setting for many studies on children's technology design as many would evaluate their design solution through a field study evaluation. Rather than viewing the dynamics of the real world context as problematic, more research studies on children's technology design regard this influence as useful and necessary for understanding the usefulness and usability of the produced solution. Furthermore, the strong focus on field studies may also come from the fact that when evaluating children's technologies the most obvious way to recruit subjects is to place the evaluation in a school environment.

Secondly, more studies report from research that employ action research for engineering purposes. Comparing this to the survey in [4], none of their research papers on mobile technologies employed action research as research method. Kjeldskov and Graham state that the lack of action research is due to a rather limited established body of theoretical knowledge and an unwillingness to implement these technologies in real life mainly due to high costs. In our discipline on children's technology design, one could argue that we already have a well-established body of theoretical knowledge even though our discipline is still young. The prevalent focus on children's role in the design process seems to have created a natural way of involving the children in the design process. One of the established theoretical foundations is the model roles for children's involvement [2]. Druin stresses the necessity of involving children on different levels for different kinds of design projects. Thus, the apparent differences between children and adults on e.g. physical or cognitive capabilities could have created a requirement for researchers and practitioners in children's technology design to develop ways of involving children.

Thirdly, given the strong focus on applied research for engineering purposes, it seems quite surprisingly that very few papers also *report* understanding as research purpose. This lack of focus was also identified for mobile technologies and Kjeldskov and Graham concluded that the quest perceived to be problematic from a user perspective is poorly represented in mobile technology research [4]. The limited focus on understanding prohibits us from a deeper understanding of the needs and requirements of children in relation to use of new technologies. Such information could potentially inform us on new and innovative products for children. On the other

hand, only two papers *report* understanding as being the research purpose. This does not necessarily imply that these other studies did not conduct activities related understanding, but the papers did not reflect such activities. Given the strict page limitations of conference proceedings, this is also shown by the fact that those two papers that report on understanding are journal papers. Furthermore, the limited focus on case studies and survey research prohibits our discipline from research results that could collect large amounts of data from, for example, children's actual use of current technologies and more general preferences of contemporary technologies.

CONCLUSION

Research methods have been discussed in many different fields for several years. Inspired by previous studies of CASE and mobile technologies research methods, we conducted a survey of 105 research papers on children's technology design. Our results show a strong focus on engineering of products as applied research and on evaluation of developed products as either field evaluations or lab evaluations. Furthermore, much research is conducted in a natural setting environment.

The survey provides a number of opportunities for future research within our discipline. First, the tight integration of children and designers/researchers could be further explored in action research projects. Secondly, different forms of research on, for example, case studies and surveys could inform us on different issues and provide different perspectives on children's use of technologies.

Our review is limited in a number of ways. First, the classification matrix was designed for and built upon research in the field of information systems. Thus, the applicability of the matrix for children's technology design research may be limited. Secondly, classifying research papers according to methods and purposes was difficult as many papers would fall into more categories, and as several papers lacked information on research methods and purposes.

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