Eija Halkola

PARTICIPATION IN INFRASTRUCTURING THE FUTURE SCHOOL. A NEXUS ANALYTIC INQUIRY
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Abstract

In information systems (IS) research, there is increasing interest in understanding complex and large-scale efforts. This study examines the complexity involved in infrastructuring within a novel context: the educational network of a Finnish city. A unique aspect is this study’s focus on children’s participation in infrastructuring. It contributes to the existing body of literature by addressing the concepts of discourses in place, interaction order, and historical body, as drawn from nexus analysis. It offers these concepts as theoretical tools for understanding the complexity of infrastructuring, and furthers exploration of user participation in IS research through a careful analysis of actor participation in the infrastructuring venture in question. The findings of this study foreground a multitude of actors, both adults and children, as well as their various activities and the versatility of the involved objects of design. The central social actors include educational officials, schools (teachers, headmasters, and pupils), researchers, and local and global companies.

Infrastructuring in this research includes planned activities concerning developed solutions, but also emergent activities for adapting planned solutions to local schools’ everyday practices, revealing the intimate intertwining of practices and technologies. In particular, the past temporal horizon and shared histories of the communities involved are highlighted in terms of the concept of the historical body. The analysis on the historical bodies of the actors foregrounded the local aspects that were appreciated, but also challenged in infrastructuring. The concept of interaction order was found to be useful for analyzing the heterogeneity, multivoicedness, tensions between local and global dimensions, and power aspects inherent in infrastructuring. As a practical implication, the nexus analytic concepts of historical body and interaction order are suggested as means of better understanding local settings and the power relationships of various actors, and are also useful for practitioners preparing for infrastructuring.

Keywords: children, discourse, information infrastructure, information systems, nexus analysis, school, teachers

Tiivistelmä


Asiasanat: diskurssi, informaatioinfrastrukturi, koulu, lapset, neksusanalyysi, opettajat, tietojärjestelmät
Acknowledgements

In this research, infrastructuring was examined as social action emerging within an educational network in a Finnish city. I acknowledge the involved educational officials and teachers for collaborating to arrange this research intervention within the city’s educational network. This study is one of the many inquiries conducted within and with the guidance of the multidisciplinary research group EveLINE (Everyday Life in Technology-Rich Neo-Communities).

I first wish to thank my first supervisor, Professor Netta Iivari, for her guidance in this thesis. I appreciate her enthusiasm and all her valuable comments, which contributed and helped me to write this doctoral thesis. I also want to address my other supervisor from the Department of Humanities, University Lecturer Leena Kuure, for her guidance. Her advice contributed to the ability of the current thesis to broaden the viewpoint of the research, particularly with regard to its methodology. I also appreciate the feedback and comments given by Professor Kari Kuutti. Appreciation must also be given to the pre-examiners, Professor Pelle Ehn (Universty of Malmö, Sweden) and Professor Pirkko Raudaskoski (University of Aalborg, Denmark), for providing me with helpful feedback. Furthermore, I wish to thank the co-authors of the papers included in this thesis within the EveLINE-group, University Lecturer Marianne Kinnula and University Lecturer Tonja Molin-Juustila, with whom I have co-operated. Moreover, the use of the concepts of information infrastructures and infrastructuring to conceptualize the future school effort under study originated from my master thesis on scientific collaboration and information infrastructures, which was supervised by Professor Helena Karasti (Luleå University of Technology, Sweden), whom I also wish to acknowledge.

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9.11.2015
Eija Halkola
List of original publications

This thesis is based on the following publications, which are referred throughout the text by their Roman numerals:


Contributions:

*Article I:* My contribution to article I concerns the related research section, in which I wrote the text on participatory design and user participation approaches in design. It especially includes the literature review that I conducted for article I involving children in design (see the section titled “Participatory design with children in light of recycling” in the article). My contribution to the discussion section also relates to these issues.

*Article II:* For the second article, I described the future school effort, as well as children’s participation in ICT developments within this effort. I also analyzed the data through a discourse analysis on children’s participation in this large-scale ICT development effort. Based on this analysis, I wrote the empirical insights section and related portions of the concluding discussion. The literature review that I wrote for article II concerned children’s participation in ICT development.
**Article III:** For article III, for which I am also the first author, my contributions included a discourse analysis of various participants in the building of the information infrastructure for the future school effort. The framework of the nexus analysis was introduced, and data were analysed to identify the central social actors and the discourses characterizing their participation within the future school effort. Based on this analysis, I wrote the empirical insights section and related portions of the concluding discussion. I also wrote the literature review for the research on user participation and information infrastructures. Furthermore, I wrote the description of the future school effort included in the research design section.

**Article IV:** I was the first author in article IV. For this article, I wrote the related research section based on the literature review I conducted on Information infrastructures and infrastructuring. I also wrote the sections on related research and empirical insights. Since I had primary responsibility for article IV, I analyzed the data from the nexus analytic perspective. The framework of the nexus analysis was followed with a discourse analysis of the data, which explored the contributions of a multitude of actors, both adults and children, in infrastructuring in the future school. Based on this analysis, I wrote the related sections of the concluding discussion.

**Article V:** For article V, I wrote the literature review concerning children’s participation. I also participated in the collaborative data analysis and independently analyzed data concerning one of the six cases within the article (i.e., the case concerning idea generation for a specific application area). Based on this analysis, I wrote the related parts of the concluding discussion. In the analysis, I used the concepts of interaction order and historical body from the nexus analysis.

**Article VI:** I was the first author of the manuscript for article VI. In the analysis of infrastructuring as social action, I applied the nexus analytic concepts of discourses in place, interaction order and historical body. I wrote the paper, and the other authors participated as the supervisors of my dissertation thesis, commenting and helping to improve the text that I wrote.
Contents

Abstract
Tiivistelmä
Acknowledgements 7
List of original publications 9
Contents 11
1 Introduction 13
  1.1 Background ................................................................. 14
  1.2 Objectives and scope .................................................. 20
    1.2.1 Answering RQ1 ...................................................... 21
    1.2.2 Answering RQ2 ...................................................... 22
    1.2.3 Answering RQ3 ...................................................... 22
  1.3 Structure of the thesis ............................................... 23
2 Related research 25
  2.1 Research on user participation and children ........................ 25
    2.1.1 User participation in ICT development ...................... 25
    2.1.2 Participation and children ...................................... 31
  2.2 Research on infrastructures and infrastructuring ................. 41
    2.2.1 Information infrastructures .................................... 43
    2.2.2 Infrastructuring .................................................... 50
3 Theoretical and methodological framework 53
4 Empirical results 59
  4.1 Article II: Children’s participation in the ICT development for
    the future school effort .................................................. 60
    4.1.1 Child as an innovative user .................................... 60
    4.1.2 Child as an informant ........................................... 61
    4.1.3 Child as a tester ................................................... 63
    4.1.4 Moving towards genuine participation ..................... 64
  4.2 Article III: Participation of various actors in information
    infrastructure building – a nexus analysis of discourses and
    concrete participatory practices ...................................... 65
    4.2.1 Discourses for challenging but also appreciating the
      installed base ............................................................ 66
    4.2.2 Discourses for equality, sustainability, continuity and
      cutting edge solutions ............................................... 67
4.2.3 Concrete participatory practices among teachers and pupils ............................................................... 69
4.3 Paper IV: Infrastructuring involving both adults and children .......................... 73
   4.3.1 Architectural and interior design solutions intertwined with ICT ................................................................. 74
   4.3.2 Pedagogical solutions intertwined with ICT ................................................................. 75
   4.3.3 Enabling solutions supporting infrastructuring activities ......................... 78
   4.3.4 Children’s role .................................................................................................................. 80
4.4 Paper V: Interaction orders and historical bodies influencing children’s participation .................................. 82
4.5 Paper VI: Infrastructuring as social action ........................................................................... 84
   4.5.1 Discourses in place: infrastructuring taking shape ........................................ 85
   4.5.2 Historical bodies and interaction orders entangled in infrastructuring .................. 95
5 Concluding discussion  .............................................................................................................. 101
5.1 Summary of the results ........................................................................................................ 102
5.2 Discussion of the results .................................................................................................... 106
   5.2.1 Discussion of the results in relation to research on participation in information infrastructure building .... 106
   5.2.2 Discussion of the results in relation to research on information infrastructures and infrastructuring .......... 114
   5.2.3 Discussion of the results in relation to the nexus analysis .................................. 117
5.3 Answers to the research questions and contributions of the research ........................................................................ 120
   5.3.1 Summary of the findings and contributions – answering research question 1 ................................................. 121
   5.3.2 Summary of the findings and contributions – answering research question 2 ................................................. 122
   5.3.3 Summary of the findings and contributions – answering research question 3 ................................................. 123
5.4 Practical implications ........................................................................................................ 125
5.5 Evaluating the interpretive research ................................................................................ 126
5.6 Limitations and paths for future work ................................................................................. 127
References ............................................................................................................................... 131
Appendix ..................................................................................................................................... 141
Original publications ............................................................................................................. 143
1 Introduction

The educational use of information and communications technology (ICT) has increasingly been attempted in Finland. The educational use of ICT was promoted within the Finnish government as early as 2007 (Finnish Ministry of Transport and Communications 2010), and these efforts continue through the Information Society Programme (2010–2020). The implementation of the Information Society Policy Programme is targeted to citizens’ ability to utilize the information society and the secure information society. Through the actions stated in the plan, the Finnish government aims to ensure that all populations and age groups possess sufficient skills to navigate the rapidly developing information society. For the educational sector, this means continuing the implementation of the Government Policy Programmes for strengthening media education. (Government Policy Programmes, Information Society 2015.) Moreover, basic education objectives in Finland aim to support pupils’ growth into members of society and to provide them with the knowledge and skills needed in life in order to improve their capacity for learning and promote their equality in life by securing adequate equity (Basic Education Act 1998/628). The national core curriculum (National Core Curriculum for Basic Education), which is determined by the Finnish National Board of Education, provides guidelines for school practices (Finnish National Board of Education 2015).

Work with these legislative groundings and strategies has been initiated and conducted in pilot projects in various Finnish schools. Research and experimentation surrounding the educational use of ICT have been continued in various, internationally linked projects and development activities in Finnish schools. (Finnish Ministry of Transport and Communications 2010.) In the current Information Society Programme, the importance of international cooperation is emphasized in the European Union (EU), the Organisation for Economic Cooperation and Development (OECD), the United Nations (UN) and other forums for cooperation due to the rapid development and global characteristics of ICT. (Government Policy Programmes, Information Society 2015.)

This research presents an effort to build an information infrastructure (Star & Ruhleder 1996), including ICT developments, for the educational network of a Finnish city. The research focuses on the participation of various actors. Here, the term ‘educational network’ refers to local schools and the municipal educational administration. Various actors, including city educational officials, local schools (including teachers and headmasters), pupils, researchers, and local and global
companies have been active in the venture. In the initial stages of the process, the
city encouraged schools in the district to submit applications for development
projects. Through this process, teachers and headmasters were invited to participate
in a ‘future school program’ to develop school culture and to determine the best
practices in pedagogy and technology use for the ‘school in the 21st century,’ or
‘the future school’. Ten schools were shortlisted as ‘Smart Schools’: that is, pilots
in technology use and the renewal of pedagogic practices. The best practices from
the Smart Schools were to be utilized in a future school, the so-called ‘Integrated
Pilot School’, which was under construction in a new town area. This school was
to be built as part of a multipurpose center, which would also include a library, a
nursery, and other facilities and services for citizens. The experiences of best
practices, which were determined from the conducted pilot projects and
implemented in the Integrated Pilot School, were to later be extended to other
schools in the city and the entire country.

1.1 Background

Traditional information systems have involved the in-house development of
isolated systems from scratch using information system (IS) methodologies
designed to support this kind of development. Traditionally, IS design started with
the uncovering and specifying of user needs, from which technical solutions were
derived. The process of beginning the development of information systems with
user needs is linked to the general assumption that the systems to be developed are
or should be designed from scratch. Moreover, traditionally, IS design
methodologies aim to develop closed systems through closed project organizations
for a closed customer organization within a closed time frame. (Hanseth 2010.)
Rather than being seen as a process, IS development has traditionally been assumed
to have specific starting and ending phases within individual development projects.
(Orlikowski 1996).

ICT use has become integrated into the everyday lives of most people. In
consequence, the scope of IS research has extended from workers and workplaces
to numerous types of people using ICT in different places (Kyng 2010). As the
nature of IS practice has changed in recent years, new challenges and perspectives
on user participation in development within IS research have emerged. Today’s IS
projects tend to affect more types of stakeholders participating in development
activities than were affected by traditional IS projects. Therefore, there is an
increased need to differentiate among different types of stakeholders, participants,
and change agents. Furthermore, unlike traditional IS participation theory and research, which required understanding participants in terms of the monolithic concept of the user, updated IS participation theory suggests exploring the fine-grained characterizations of stakeholders and participants. In this theory, stakeholders are defined as those who are affected by a solution; whose acceptance and use of said solution could be problematic; and who are, therefore, logical candidates for participation in solution development or implementation. Participants are suggested to be defined as the subset of stakeholders actually given the chance to participate in solution development and/or implementation activities. (Markus & Mao 2004.)

This research will present a careful analysis of the participation of various actors (cf. Markus & Mao 2004), both users and other kinds of stakeholders, in this complex information infrastructure building effort. Various actors within the local educational network, as well as global network actors, have been active in the effort. To study the participation of these involved actors, this study, in addition to IS research, utilizes the literature on user participation within the field of human-computer interaction (HCI). The study also relies on the literature on users’ roles and participation in ICT design, which falls within the research field of participatory design (PD) (Schuler & Namioka 1993). Finally, it draws from the literature on the cooperative design practices of the Scandinavian countries (Greenbaum & Kyng 1991) and on participatory design and contextual inquiry in the U.S. (Beyer & Holtzblatt 1998).

Novel in this research is its particular focus on school children’s participation among the group of relevant actors. Though children are a growing group of technology users, they are seldom defined as users of ICT in the IS literature. Thus far, children have been mentioned in IS research as users or stakeholders of certain kinds of ICT; however, their participation in development work has not been addressed. Moreover, children’s participation has also not been previously studied in the context of complex information infrastructure development efforts. Children’s participation has been examined in existing HCI studies on interaction design and children (IDC); however, these development efforts have been relatively small-scale, with the articles describing particular design or evaluation sessions involving children (e.g. Druin 1999, Druin et al. 1997, Scaife & Rogers 1999, Scaife et al. 1997). The integration of children into complex development ventures, such as information infrastructure building efforts involving a multitude of actors, is evidently more challenging. Some studies have described children’s participation in more complex cases, involving longer time spans or more partners; however,
though these studies are relevant for this research, they are usually carried out within other disciplines. For example, children’s participation in complex efforts has been studied within the fields of environmental and urban planning (e.g. Francis & Lorenzo 2002, Thomas & O’Kane 1998, Saad-Sulonen & Cabrera 2008, Saad-Sulonen & Horelli 2010). There are also studies on children’s participation that are based on the inclusive perspective of children’s right to participate in decision-making that affects their lives (e.g. Chawla & Heft 2002, Hart 1992). In these fields, a child’s participation has been understood in the context of the process of sharing decisions affecting a child’s life and the life of the community within which the child lives (Hart 1992: 5), as well as within the context of advocating children’s ‘genuine’ (e.g. Chawla & Heft 2002) participation. Such literature, which involves many inclusive aspects, motivated this research interest on engaging and strengthening children’s participation.

Recent changes in IS solutions have also contributed to increased interest in understanding more complex efforts and the evolution of large-scale, complex technological systems (Hanseth 2010). Within the systems engineering field, the use of ‘coalition’ design has been suggested to manage the complexity inherent in the assembly of independently controlled and managed systems. Such design work has been suggested for both new and existing systems. (Sommerville 2012.) The attention of IS scholars has also been drawn to the increasing scope and scale of ISs (Pollock & Williams 2010, Williams & Pollock 2012). Accordingly, some researchers have recommended a greater focus on the shaping of large-scale workplace ICTs, such as packaged workplace technologies, rather than a focus on single-site implementation (Williams & Pollock 2012). ‘Biography’ studies have been introduced to help researchers understand the implications of ICTs on organizations. This study approach is preferred to the method of studying technologies at particular locales or in particular moments within organizations. (Williams & Pollock 2012) Overall, today’s solutions are significantly different from the traditional IS solutions, as they integrate a number of systems across organizational and geographical borders (Hanseth 2010); are connected and intertwined with complex information infrastructures (e.g. Ciborra 2000, Hanseth 1996, Star & Bowker 2002, Star & Ruhleder 1996); and involve significant numbers of independent actors, developers, and users (Hanseth 1996).

The tradition of Science and Technology Studies (STSs) provides concepts and frameworks for the analysis of large technological systems (LTSs), such as infrastructures (Hughes 1987). Traditionally, infrastructures have involved significant technical and material background structures (e.g. water pipes,
electricity supply channels, road networks, the Internet). These can be understood as the platforms on which the other structures depend or as the platforms that run ‘underneath’ the actual structures (Star & Bowker 2002). However, to cover the multidimensionality of use contexts and practices (Star & Ruhleder 1996) and to analyze large-scale technological systems (Star & Bowker 2002), the concept of information infrastructures has been recommended.

This research utilizes the literature on the development of information infrastructures, which characterizes the concept from different perspectives. The design of information infrastructures has been defined as a highly complex, continuous and evolving process (Hanseth 1996, Star & Bowker 2002, Star & Ruhleder 1996). To conceptualize the future school effort explored in this research, the socio-technical approach of information infrastructures, as defined by Star and Ruhleder (1996), has been used. Participatory processes for infrastructure development have previously been discussed in the literature (e.g. Hanseth & Lundberg 2001, Karasti & Syrjänen 2004, Neumann & Star 1996); however, in the future school effort, the participatory process emerged without our intervention. Thus, this study can be seen to be located between the research arguing for participatory design in information infrastructure development efforts (Neumann & Star 1996) and the research discussing participatory design ‘in the wild’ as a natural part of information infrastructure building (Karasti & Syrjänen 2004). This study contributes to these streams of literature by examining the participatory process of the future school effort and by focusing on participation of users and other kinds of stakeholders, as well as their forms of participation.

Furthermore, to describe the process of constructing the future school, the concept of infrastructuring (Star & Bowker 2002) has been introduced. In the research literature, the concept of infrastructuring has been suggested to be appropriate for characterizing the building and evolution of information infrastructures (Star & Bowker 2002, Pipek & Wulf 2009, Björgvinsson et al. 2010, Björgvinsson et al. 2012a, Karasti 2014, Karasti & Baker 2008). Moreover, infrastructuring as an activity is considered to include various kinds of people – not only professional designers (Karasti & Baker 2004, 2008, Karasti & Syrjänen 2004, Pipek & Wulf 2009). As a result, potential ‘users’ and ‘designers’ have grown in both numbers and diversification, expanding to include citizens and varied kinds of publics (Björgvinsson et al. 2010, Björgvinsson et al. 2012a, Karasti 2014). Despite the extensive and long-term research interest, many gaps and limitations have been identified in the existing research on infrastructuring in PD. Specifically, on the basis of a literature review of infrastructuring in PD, a number of paths for
further research have been suggested. First, the focus of PD studies could be
broadened from infrastructuring activities and technology to the embedding context
of practice – that is, the socio-technical nature of infrastructuring. The
acknowledgment of longer temporal horizons in PD research has also been
suggested. Current literature on infrastructuring in PD focuses mainly on the scopes
of communities and organizations. Therefore, multi-sitedness and the local-global
dimension of the multi-scope, socio-material-technical political assemblages and
processes of large-scale infrastructuring in PD should also be explored.
Additionally, political aspects within this research field should be examined in
more detail. It has been remarked that infrastructuring deals with heterogeneities
and multivocalities, multiplicities and marginalities, inclusions and exclusions,
silences and absences, and standards and invisible work – all of which add further
complexity to ongoing power-related debates. This situation calls for more
attention to be paid to non-participants and non-users. (Karasti 2014.) Hence,
research on infrastructuring in PD needs to be focused on socio-technical aspects
in addition to technological aspects. These insights into potential paths for research
on infrastructuring in PD may also inform other infrastructuring studies,
particularly those interested in participation, such as this study.

In infrastructuring research, the nexus analytic approach (Scollon & Scollon
2004) is useful for recognizing the interconnectedness between small-scale
development efforts and entire infrastructuring efforts. Nexus analysis (Scollon &
Scollon 2004) may extend a research perspective from the micro level to the
organizational and institutional levels of social analysis (Scollon 2001b), which are
necessarily intertwined in the analysis of a complex case of this kind. The nexus
analytic framework is considered particularly valuable in the study of such complex
processes, since it assumes (1) that broader social issues are ultimately grounded in
the micro-actions of social interaction, but also (2) that the most mundane of micro-
actions form a nexus, through which the largest cycles of social organization and
activity circulate (Scollon & Scollon 2004). Hence, nexus analysis guides to
approach the social action under study ethnographically within the everyday-life
context of the various actors. However, at the same time, the micro-level
instantiations of social action are connected to the macro-level – that is, to the
broader context shaping infrastructuring. Furthermore, nexus analysis provides the
tools to explore participation as social action (Scollon 2001b) from the points of
view of both concrete practices and wider discourses. In this research,
infrastructuring is examined as social action within the educational network of a
Finnish city. The focus of this longitudinal case is on various sub-projects involving
a multitude of actors. Infrastructuring as social action is seen in this research as occurring at the intersection of the historical bodies (Nishida 1958) of the participants in the action; the interaction order (Goffman 1983) that the participants mutually produce; and the discourses in place, which enable actions or are used by participants as means in their actions (Scollon & Scollon 2004: 153–154). The term ‘historical body’ refers to each participant’s individual history, including their social identity and role within the action. The term ‘interaction order’ refers to the many possible forms of social arrangements of relationships. The term ‘discourses in place’ concerns the process of selecting for empirical analysis the relevant discourses for social actions of interest (Scollon 2001b).

To analyze infrastructures, the nexus analytic concepts of discourses in place, historical body, and interaction order facilitate a closer look at the sociocultural histories and arrangements behind social action (Scollon & Scollon 2004). They also foreground the transparent background and historical elements of the infrastructure acknowledged in the literature (Star & Ruhleder 1996). Additionally, the concepts of interaction order and historical body facilitate the exploration of longer temporal timescales of infrastructuring, especially with regard to past temporal horizons; the shared histories of the communities involved; and the multi-sitedness, multivocalities, and political aspects inherent in infrastructuring. Hence, these nexus analytic concepts facilitate ‘infrastructural inversion’ (Bowker 1994), or the foregrounding of the background elements of infrastructures. Moreover, the framework of nexus analysis guides the researcher not only on how to enter and navigate a nexus of practice of interest, but also on his or her inevitable participation in initiating change within this nexus of practice.

This research focuses on the participation of the multiplicity of actors within the future school effort. The participatory process in this effort will be examined through the various views of the actors involved, as studied through a discourse analysis of thematic interviews of Smart School teachers and key persons responsible in the effort. In addition, this study analyses research material collected from school children through a research intervention. Through discourse analysis, this study highlights these multiple voices of the actors involved. In particular, this research will inquire into children’s participation in the complex information infrastructure effort – a topic that has not yet been studied in the IS field. This research includes children as targets of study and as an important user group that has not been studied as widely as that of workers in IS research. (Vodanovich et al. 2010.) In fact, extant IS research has largely overlooked the role of children (Vodanovich et al. 2010). Overall, this study addresses the role of ICT in the school
context, which is a relatively new and very challenging context for IS research, since the adoption of ICT in such a setting is a complicated process involving the intermingling of ICT and pedagogy. For these reasons, studies like the present one are needed to understand and alleviate existing challenges.

The focus of this study and related research fields (i.e. IS, HCI, IDC, socio-technical approaches to information infrastructures and infrastructuring, and nexus analysis) are presented and summarized in figure 1.

![Figure 1: The focus of this study and related research fields.](image)

1.2 Objectives and scope

The aim of this research is to shed light on the process of infrastructuring, with a particular emphasis on its participatory aspect. The research questions addressed by this dissertation are as follows:

- Research question 1 (RQ1): How can one characterize the participation of various actors in the complex process of building an information infrastructure for an educational network?
- Research question 2 (RQ2): What are the characteristics of children’s participation in this effort?
Research question 3 (RQ3): What are the characteristics of infrastructuring in the school context?

This dissertation work includes six articles, each of which provides a partial solution to the research problem. In table 1, each research question is shown in relation to the article in which it has been discussed. The contributions of the articles are combined in this dissertation summary.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Article I</th>
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1.2.1 Answering RQ1

The third article (article III) answers research question 1. It analyzes the participation of various actors, both adults and children, in information infrastructure building within the future school effort as a novel context within this research field. The future school effort is discussed with a particular focus on its participative aspect. The central social actors contributing to this effort are identified, and children are recognized as a relevant and novel group of stakeholders in the IS research field. This article also presents literature on information infrastructures and applies the socio-technical approach on information infrastructures in order to conceptualize the complex future school effort. Furthermore, the article offers a nexus analysis of discourses and concrete participatory practices. A number of discourses justifying the wide-ranging participation of various actors and concrete participatory practices are identified. Ultimately, the article advocates more genuine participation of teachers and pupils as parts of the information infrastructure building process, e.g. through the creation of enabling practices. This article complements the research theme of participatory processes for information infrastructure development.
1.2.2 Answering RQ2

Research question 2 is answered by articles I, II, and V. The first article (article I) provides a literature review of children’s participation within the research fields of IS, HCI, and PD, as well as the related research field of IDC.

Article II discusses children’s participation in ICT developments for the future school effort from the perspective of their positions, as assigned to them during the interviews. Based on the literature review, a gap concerning children’s participation in ICT development processes is revealed within the research field of IS. Though children represent an active group of technology users, IS literature seldom views children as participants in the ICT development process. Furthermore, a review of IDC articles focusing on large-scale efforts involving ICT reveals that even in the few efforts that do include children, their role is not very strong. However, the article does find some literature on children’s participation in large-scale efforts within other research fields. The findings of article II are reflected and discussed against this literature. A nexus analysis is used as a theoretical and methodological framework.

Article V explores the nexus analytical concepts of interaction order and historical body in terms of their influence on children’s participation. One of the six empirical cases discussed in article V considers children’s participation in idea generation for learning environments within the future school infrastructuring effort. In this case, children participated in an arranged research intervention that allowed them to express their expectations and ideas concerning the proposed Integrated Future School. The background voices of ‘others’ involved in and informing design through the participating children are reflected in this article. The practical implications of the identified multiplicity of voices in children’s contributions are discussed with regard to ways to improve responsiveness to the contributions of children involved in the studied effort.

1.2.3 Answering RQ3

Research question 3 is answered by articles IV and VI. These articles present a concept of infrastructuring that challenges the traditional, project-based assumptions of IS development. A nexus analytic framework combining both qualitative and participatory approaches was utilized in both articles.

Article IV explores infrastructuring involving both adults and children in the future school effort. It also characterizes the multitude of actors, both adults and
children, involved in this effort, as well as their various activities and outcomes in the context of infrastructuring. The study expands infrastructuring to encompass pedagogical, architectural, and interior design, as well as enabling issues as possible aspects together with ICT.

Article VI discusses infrastructuring as social action. This in-depth analysis is sensitized to the three facets of social action: discourses in place, discourses emerging here and now, and the interaction order among the various stakeholders in the effort and their historical bodies, all of which shape infrastructuring. A nexus analysis was used as a theoretical tool for developing a better understanding of the complexity, the multiplicity of voices, and the contributions of the various actors involved. The concept of the historical body was used to study the historical aspects inherent in infrastructuring. Interaction order was found to be useful for analyzing the heterogeneity, multivoicedness, tensions between local and global dimensions, and power aspects inherent in infrastructuring.

This study contributes by examining the participatory process of this complex case, with a focus on the participation of users and other kinds of stakeholders, as well as on the forms of their participation. In particular, this study will inquire into children’s participation in complex information infrastructure efforts – a topic that has not yet been studied in this field.

1.3 Structure of the thesis

The structure of this dissertation is as follows: The next section presents related research, including literature on user participation within IS research and, more specifically, literature on children’s participation within HCI research. It also includes some studies on children’s participation in large-scale efforts within other disciplines. The second section also introduces the concepts of information infrastructure and infrastructuring in more depth and discusses literature related to the designing of information infrastructures. The third section describes the research method used, as well as the data gathering and analysis procedures implemented. The fourth section outlines the empirical results, and the fifth section presents the concluding discussion, along with implications for research and practice and limitations and paths for future research.
2 Related research

The following sections will discuss earlier IS and participatory design (PD) research on user participation, with a particular focus on the role of children in such participation.

2.1 Research on user participation and children

It has long been acknowledged that users should, in some way, take part in ICT development efforts (Markus & Mao 2004). Different views of user participation in ICT design have emerged through various technology development traditions and design methods. User participation is a traditional topic of study in IS research; however, it also continues to be a vibrant theme, particularly due to new and challenging IS contexts that pose novel challenges for user participation (Markus & Mao 2004).

In general, user participation is deemed to be important in IS research because it is expected to create buy-in among users, to improve system quality and to improve relations between developers and users (Markus & Mao 2004). However, research has shown very mixed results concerning the connections between user participation and system success. The participation of users in systems development projects may reflect only symbolic tokenism, in which users are not given influential roles or any real opportunity to affect decision-making. There has been criticism that participation may be framed as a managerial approach that fails to challenge power relations within systems development projects. (Howcroft & Wilson 2003.)

The following sections present a brief review of design traditions with different origins and foci, as well as a variety of views of users in ICT design.

2.1.1 User participation in ICT development

User participation in ICT design draws on the socio-technical perspective of organizational and technical change that explicitly addresses worker participation and the quality of working life (Ehn & Kyng 1987). Socio-technical approach aimed to take into account both humanistic values and economic efficiency (Kubicek 1983). The socio-technical system acknowledges both the social and psychological impact of technology on workers (Mumford 1987). During the 1960s, research on systems design was based on rationalistic, scientific management and
the emergence of systems theory approaches (Ehn & Kyng 1987). In Scandinavian industries, the socio-technical approach was initially implemented in Norway (Norwegian Institute for Social Studies); however, the approach was most widely used in Sweden, where it was adopted during the rapid emergence of technological and structural changes in the late 1960s. The socio-technical approach was further developed over the course of a number of practical projects on industrial democracy, which sparked interest in socio-technical experiments. Such experiments were first initiated in Norway and, later, Sweden through the joint efforts of central unions and employer organizations in both the private and public sectors. (Ehn 1993.) The socio-technical approach was also applied to the design of computer systems in Britain (Kubicek 1983). However, most of these socio-technical experiments were controlled by local management, thus limiting the achievement of the aim of democratic participation (Ehn 1993).

From a socio-technical perspective, user participation is seen as a mechanism that enables the representation of all user interests and that resolves the inherent conflicts of interests among various parties (Mumford 1983). Mumford (1983) divided user participation into three types: consultative, representative, and consensus participation (cf. Mumford 1987; Mumford & Henshall 1979). In ‘consultative’ user participation, there is a great deal of consultation and discussion with users (e.g. staff at every level of the user department and workers of the organization), although the traditional systems designers are the ultimate decision-makers with regard to systems design and the related structuring of the work. In ‘representative’ user participation, representatives of different kinds of user groups, who are either selected by the management or elected by other users, become involved; these representatives are assumed to represent the interests of their constituents and are assigned some decision-making power in the formed design group. Inherent in this arrangement, however, is the problem that representatives may not correctly interpret their constituents’ interests. Finally, the ‘consensus’ participation approach attempts to enable those affected by a decision to take part in the decision continuously throughout the design process. Thus, in this approach, user representatives have decision-making power in the design process. (Mumford 1983, Mumford & Henshall 1979.) It is critical that all interests be represented, that the members of the participative forum are appropriately selected or elected, and that groups at different organizational levels are established when required. When a structure for participation is created, decisions concerning the extent to which certain groups of participants will be allowed to influence decisions must be made (Mumford 1983). Furthermore, Mumford (1983) emphasizes the structure of
participation, while enabling participation by using a representative group as the vehicle for decision making.

In Scandinavia, the socio-technical approach was considered inadequate for democratizing the design and use of computer-based systems in the workplace; moreover, its theory and practice in the context of work democratization were criticized (Ehn 1992, Ehn & Kyng 1987). In opposition to the socio-technical tradition, some Scandinavian researchers and trade unions developed the work-oriented approach to the democratization of the design and use of computer-based systems (Ehn 1993). This approach was based on a historical, social, and political understanding of the Scandinavian situation, and it allows trade unions to play a major role in the design and use of computer-based systems (Ehn 1992, Ehn & Kyng 1987). The work-oriented approach was grounded on the ideal of skilled workers and designers cooperating to design computer artifacts as tools for skilled work (Ehn 1992, Ehn 1993). Thus, the collective resource approach was developed as an alternative to advanced participation, work organization, and democracy in the development and use of computer-based systems and tools. Workplace democracy was emphasized through users’ participation in decision-making, which enabled workers to influence the design and use of computer applications in their workplaces. The active role of local trade unions in the democratization of the design and use of new technology was weighed (Ehn 1988, Ehn & Kyng 1987), and central trade union activities were designed to improve local work conditions through national agreements, educational improvements, and design projects (Ehn & Kyng 1987).

At the end of the 1960s, new Norwegian legislation focusing on industrial democracy increased workers’ ability to influence new technology. In cooperation with researchers, the Norwegian Metal Workers’ Union (NJMF) initiated a research project (Ehn & Kyng 1987) on the theme of workers’ participation and skill in the design and use of computer-based systems (Ehn 1993). The ideas of the NJMF project (e.g. working with people, trade unions arranging educational activities) were experimentally implemented within the leading Scandinavian projects, all based on the idea of involving workers in the design and implementation of the tools and machines they used in their work (Ehn & Kyng 1987). Grounded on this Norwegian strategy and the resulting experiences, the DEMOS (DEMOkratiske Styringssystemer) research project (Ehn & Sanberg 1979) was initiated by the Swedish Trade Union Federation (Ehn & Kyng 1987), the DUE (Demokrati, Udvikling og Edb) project was launched in Denmark (Kyng & Mathiassen 1982), and the UTOPIA (Utbildning, Teknik, och Produkt I Arbetskvalitetsperspektiv)
research project (Bødker et al. 1987, Ehn 1988) was established by the Nordic Graphics Workers’ Union (Ehn & Kyng 1987). Furthermore, the Florence Research Project (on the Application of Computers in Nursing) in the health sector developed approaches for encouraging nurse collaboration in the development of work and IT in hospitals (Bjerkness & Bratteteig 1987). Later, in the 1990s, further developments were made to the Scandinavian approach; these included a project launched by the National Labour Inspection Service (AT) office in Denmark (Bødker et al. 1993), the EureCoop/EuroCode projects, and the large European Union projects involving research institutions and research partners (Greenbaum et al. 1995).

Users’ roles and participation in ICT design and power relations have also been areas of interest within the PD research field (Schuler & Namioka 1993). The PD tradition was originally focused on worker participation in systems development, a view that originated with Scandinavian research projects on user participation in computer systems development (see articles in Bjerknes et al. 1987) and cooperative design practices (Greenbaum & Kyng 1991). The cooperative design approach highlights the politics of the design process, acknowledging the conflicts inherent in this process that emerge, for example, between managers and workers using the process or between user groups and systems designers with different system needs (Greenbaum & Kyng 1991). The term ‘cooperative design’ has been particularly widely used to refer to the cooperation between users and designers in the design process of computer applications (Bødker et al. 1993). The cooperative design approach is based on the ideal that computer systems created for the workplace need to be designed with full user participation – both from a democratic point of view and to ensure that competencies central to the design are represented in the design group. The cooperative design process highlights the issue of how computers are used in the context of work organizations in use situations. (Bødker et al. 1993, Greenbaum & Kyng 1991.) To achieve full user participation, cooperative design practices place special emphasis on the importance of training and active cooperation (Bødker et al. 1993, Greenbaum & Kyng 1991), rather than on token representation in meetings and committees (Greenbaum & Kyng 1991). To achieve democracy, cooperative design promotes techniques involving increased use of users’ everyday experiences and professional skills in design over the more traditional and often overly abstract experienced professional system design methods. It also addresses the need to secure resources for user participation in design projects. Furthermore, in cooperative design projects, designers act as coordinators, shifting the role of system developers from one of project
management to one of project facilitation, ultimately creating a forum in which users can take active part in design activities. (Bødker et al. 1993.)

Within the PD or cooperative design tradition, however, political concerns have decreased in importance. In the field of PD, the political issues of power and industrial democracy have been deemphasized, and the focus has shifted to making the system design process more co-operative and participatory. (Kraft & Bansler 1994.) Workplace democracy and trade unions no longer play an important role in PD. Instead, today, ICT use has become integrated into the everyday lives of most people. This shift has broadened the scope of PD research from workers and workplaces to numerous types of people using ICT in different places. (Kyng 2010.) In addition, the principles of the Scandinavian tradition have recently been explored (Simonsen & Robertson 2013). Researchers have argued for use of PD approaches also in today’s design practices with decreased political interests in order to safeguard user interests (Bratteteig et al. 2013, Kyng 2010). Furthermore, different kinds of user representatives have been suggested to represent actual users and ensure various users’ interests, since the participation of users has grown more complicated as a result of the complexity of today’s ICT development (Iivari et al. 2009, Kyng 2010).

Whereas European participatory design emphasizes democratic participation, North American corporations focus on methods to promote user participation, such as the Joint Application Design (JAD) tradition and similar methodologies. These seek to promote business goals designed to increase the efficiency and effectiveness of technical design. The development of user-involving design methods in the US originated in large US corporations engaged in the production of office technologies, such as the JAD methodology, that integrated structured meetings with users (Asaro 2000) as an extension of the existing International Business Machines (IBM) Corporation design methodology (Carmel et al. 1993).

Furthermore, the research field of HCI links design and the use of computer systems with a focus on developing a more holistic view of human-system interaction – one that moves away from the purely technical approach and automation. HCI investigates the ways in which people interact with computer systems and develops concepts and methods for the design of more usable system interfaces. (Bannon 1991.) Usability issues in previous HCI research have been explored beginning with the ‘look and feel’ of software and focusing on the generic aspects of the human-computer dialogue shared by almost all users by the product developers (Grudin 1991). In addition, user-centered design (UCD) research emphasizes the need for applications to be, not only user-friendly, but also more
deeply rooted in the practices of the people using them (Greenbaum 1993). The 
UCD approach to design also emphasizes the end users of a product by focusing on users throughout the entire UCD product process (Norman & Draper 1986). In the UCD approach to contextual design (Beyer & Holtzblatt 1998, Holtzblatt & Beyer 1993), designers adopt an anthropological stance to building systems that are both useful and usable. UCD principles have also been incorporated into International Organization for Standardization (ISO) documents (Markus & Mao 2004) advocating active user involvement1 (Maguire 2001, Markus & Mao 2004).

User participation is a traditional topic of study in IS research, within which the participation of users in system development and the role of this participation in IS success have generally been linked. The role of user participation in ‘system success’ has been defined in terms of system quality, user information satisfaction, user acceptance, and system use, and it is also affected by various contingencies, such as task and system complexity. User participation, however, is still recommended, since such participation is expected to contribute to system success through the creation of users’ buy-in, the improvement of system quality, and the improvement of relationships between developers and users. (Markus & Mao 2004.)

However, as the nature of IS practice has changed in recent years, new challenges and perspectives on user participation in development have also emerged. Traditional IS participation theory explanations for participation’s effects on system success have been criticized as exhibiting logical inconsistencies and deficiencies in light of today’s IS development initiatives, which are very different from the initiatives that were current when IS participation theory was developed. In response to this criticism, the traditional participation outcome concept of ‘system success’ has been redefined. The first step in this redefinition involved making explicit the concept of the actor, which is argued to be largely implicit in traditional theorizing. Furthermore, different types of stakeholders, participants, and change agents have been differentiated. (Markus & Mao 2004.)

Today’s IS projects often affect many more stakeholders than such projects did when IS participation theory was first proposed. Not only do today’s IS projects tend to affect more users relative to the number of people who can participate in development, but they also tend to affect more types of users, including whole groups that may not be available to participate in development activities. Moreover, current IS research argues for a clear direction for new theoretical development to hypothesize a link between user participation during system development and

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1 In this study terms of participation and involvement are used as synonyms.
system acceptance and use as a function of who participates and who does not. The key to such theoretical development is a fine-grained conception of participants in terms of their structural positions within organizations (e.g. executive champions, process owners, functional area or business unit managers, employee end users, business customers, end consumers) and the participant proportions of various affected stakeholder groups. (Markus & Mao 2004.)

Research results also present mixed connections between user participation and systems success. Consequently, participation may be framed as a managerial approach that fails to challenging existing power relations within systems development projects. (Howcroft & Wilson 2003.) As the context of IS research has changed, such that modern IS projects affect more stakeholders than traditional IS projects (e.g. Markus & Mao 2004), new challenges in IS participation research have emerged due to the increasing complexity of these cases. Moreover, in the PD research field, most contemporary PD experiments are rather small-scale, focusing on standalone applications, indicating a low organizational complexity of projects, and suggesting applications of ICT in organizations that lack strategic value (Oostveen & van den Besselaar 2004). Clearly, more research on participation within these new, more complex cases is needed.

2.1.2 Participation and children

There is a lack of research in IS literature on children’s roles in ICT development efforts: that is, children have been mentioned as stakeholders, but their participation in development work has not been addressed. However, as children are increasingly using technologies, their participation in technology design has attracted the interest of participatory design and HCI researchers inspired by the cooperative design practices (Greenbaum & Kyng 1991) of Scandinavia and the participatory research (Schuler & Namioka 1993) and contextual design (Beyer & Holtzblatt 1998) traditions of the US. A significant literature base has been generated on the subject already (e.g. Druin et al. 1999, Guha et al. 2005, Jensen & Skov 2005, Read et al. 2005). In particular, the topic has been addressed within a research community on IDC associated with HCI research. The design models of UCD (Norman & Draper 1986), contextual design (Beyer & Holtzblatt 1998), learner-centered design (Soloway et al. 1994), participatory design (Carmel et al. 1993, Greenbaum 1993, Schuler & Namioka 1993), informant design (Scaife & Rogers 1999, Scaife et al. 1997) and cooperative inquiry (e.g. Druin 1999, Druin et al. 1997) have all been applied to involve children in the design process. Children have been
primarily involved in particular design or evaluation sessions, with researchers presenting the methods used in working with children and/or the resultant design or product achieved during the cooperation (see e.g. Druin 1999, Druin et al. 1997, Scaife & Rogers 1999, Scaife et al. 1997).

There is variety in terms of users’ (either adults’ or children’s) participation and their positioning in the design process (Nesset & Large 2004). The cooperative inquiry approach, in particular, has adopted traditional participatory design techniques adapted for working with children and respecting children as design partners (Druin 1999, Druin 2002, Garzotto 2008). Consequently, the initial focus on children as users of technologies and on the consequences and impacts of technologies on children has shifted to a perspective of children as testers, informants and design partners (Druin 2002). Druin (2002) distinguished these four main roles (users, testers, informants, and design partners) that children play in the technology design process. Researchers may assign children the user role in order to understand the impact of existing technologies on child users – and, consequently, to change future technologies or enhance future educational environments. Children may also take on the informant role during the various stages of the design process, starting with the preliminary phase, before any technology has been developed, and continuing to the phase in which the technology development has been completed. Children may also be involved as testers of technology prototypes that have not yet been released to the world. Finally, in the design partner role, children are considered to be equal stakeholders in the design of new technologies. All of these possible roles present difficulties, complexities, demands, and possibilities for both children and adults and may have varying impacts on the technologies created. (Druin 2002.)

**Influence of adult participants in ICT design with children**

In addition to researchers and developers of new technologies, there are other adult parties, including parents and teachers, involved in ICT design with children. Developers commonly communicate with these parties instead of asking children or students directly about what they may need. (Druin 2002, Druin et al. 1999.) This has been suggested to occur partially because of the traditional power structure between adults and children (in which adults are positioned as ‘all-knowing’ and children as ‘all-learning’), which stems from the dependence of young people on their parents and teachers for everything from food and shelter to educational experiences. These relationships between adults and children may, in certain
situations, make it difficult for children to voice their opinions with regard to deciding what technologies should exist in schools or at home. (Druin 2002.)

The IDC literature has also emphasized the importance of understanding that there is ‘a set of influential adults involved,’ and that this set of adults may determine what technologies children use, assist in this use, and even design the look and feel of the interface. Children primarily use technology at school or at home; thus, the context of use tends to occur around family or friends or in educational contexts in IDC (Read & Bekker 2011). Consequently, adults within these home and educational contexts have significant influence over children’s technology use. There is still a need for research on the interaction between children and computational and communication technologies to take into account home and play contexts, since such research has thus far focused on classroom and educational settings, with insufficient attention being paid to the roles of parents and siblings. (Read & Markopoulos 2013.)

Especially in educational environments, the power structures between adults and children significantly influence the design process that positions adults in power. This process is difficult to overcome in order to, for instance, impose a different model of interaction positioning adults as facilitators for children’s ideas. For example, in one studied process in which university staff, parent helpers, and school children attempted to design a school web site together, the educational environment contributed to many of the children’s and adults’ expectations, including expectations about the adults being in charge, about acceptable behavior, and about the types of activities that would occur. In this case, it was noted that the children expected to be told what to do by the adults – a situation that was exacerbated because the event was held in school, during a school day. (Read et al. 2002.)

Due to these acknowledged power structures, teacher involvement has been seen to be undesirable, since the existing power relationship between teachers and students could lead to a situation in which children feel tested or compelled to perform well. (Druin et al. 1999, Pardo et al. 2008.) However, the power relations between teachers and children can also be equalized in design sessions. By introducing teachers from other schools and then, after a delay, introducing them to the participating children, the children can be influenced to treat the ‘teachers’ differently than they normally might. The children in a design team may even become mentors for the teachers, who may ultimately learn from the children. Furthermore, design activities outside the school environment may affect power structures between adults and children. (Druin et al. 2001.)
When approaching technology, teachers’ and children’s traditional roles can be reversed when both the children and the teachers are unfamiliar with the technology in question. This situation gives both parties an opportunity to elaborate on shared meanings and practices (Pardo et al. 2005, 2006); that is, the children do not expect the teachers to know everything, and the teachers may assume learner roles (Pardo et al. 2006). The role of children has also been discussed in the context of evaluating educational software intended for use by children. Thus, while existing power relationships have been viewed as keeping teachers on the periphery of child-based evaluations, in this context, a combination of both expert and user-based evaluation elements is valued. Furthermore, in the context of educational software, the inclusion of teachers as expert educators in the evaluation process improves the diagnostic power of evaluation and its sensitivity to pedagogical issues. It has also been noted that both designers and children welcome teachers in the evaluation process. (Pardo et al. 2008.)

Adults may also help children overcome traditional power structures by, for example, wearing informal clothing and avoiding interviewing questions (Druin 1999). In this way, researchers can minimize their status as ‘authority figures’ and make it easier for children to feel comfortable sharing their thoughts (Druin 1999, Druin et al. 1999). Similarly, rewarding child design partners for participating through small technology gifts or kicking off design processes with fun, informal events have been found to be important in building relationships between adult and child design partners (Guha et al. 2013).

In addition to taking into account these power-related aspects, participating adult researchers can also support children’s participation in design processes through domain-specific expertise. For example, visual artists or educators can support technology design processes with their expertise and experience (Druin 2002). Furthermore, child researchers may have special experiences or viewpoints capable of supporting technology design processes that other partners may not be able to mediate (Druin 2002, 1999). Further, the literature has shown that bringing in adult experts from other fields may contribute to and influence children’s participation in design processes (e.g. Mazzone et al. 2010, Moraveji et al. 2007, Scaife et al. 1997, Scaife & Rogers 1999).

Moreover, it has been emphasized that, although children are not able to do everything that adults can do, they should nevertheless have an equal opportunity to contribute to design processes in any way they can (Druin 2002). Furthermore, it has been strongly argued in the literature that adults and children should be seen as equal partners in design teams (e.g. Druin 1999, 2002, Druin et al. 1999, Guha 2002).
et al. 2013). However, there are also certain roles in which adults maintain typical adult responsibilities. For example, adults on a design team must provide structure to design sessions and maintain the pace of these sessions in order to accomplish necessary design tasks. Adult design partners are also responsible for the basic flow of design sessions – and, occasionally, an adult may need to step into a caregiver role. Adults may also need to intervene to facilitate co-operation among children. It is important that adults fulfil these typical adult roles and maintain their roles as partners throughout the design sessions. Instead of trying to change all pre-existing adult/child relationships, focus should be placed on the relationships that exist in the context of the design process, since children are able to differentiate between different contexts. (Guha et al. 2013.) Allowing children to make their own decisions about how and when to use technology will also help children feel empowered. It has also been recognized that providing a variety of technology interaction options for children may motivate their use of technology, which can later be considered in design arrangements (Druin et al. 1999).

Furthermore, as discussed above, parents represent an adult group that has influence over design sessions due to existing power structures. Parental permission must be obtained before children can participate in a design team. Moreover, design activities may be located in a school, in a lab outside of school, or even in a researcher’s home – all of which represent destinations that children need to be taken by their parents. (Druin 1999.)

Team dynamics influencing collaborative ICT design with children

The power structures between adults and children may affect design sessions in various ways. Different aspects of power relations and team dynamics may manifest during design workshops conducted by intergenerational design teams (i.e. teams involving both adults and children) (Druin 1999, 2002). In design sessions, bringing together a single adult and a group of several children may result in a team dynamic that feels like a classroom, ultimately reducing productivity. Similarly, it has been suggested that a group with a single child is also not productive in a collaborative design experience. (Druin et al. 1999.) In IDC prototyping, team dynamics have been reported to influence on children’s participation (Druin 1999). It has been suggested, in fact, that two to four children paired with two to three adults may create a productive brainstorming experience (Druin & Solomon 1996, Druin et al. 1997). Guidelines aiming to decrease the influence of existing power
relations have also been suggested in the context of usability testing (Hanna et al. 1997).

In addition to the power structures that exist between adult and child participants, children’s skills and development stages also influence design sessions. A child’s age has been considered to be one aspect influencing the productivity of prototyping workshops. Children aged 7 to 10 years old have been considered to be open to new ideas, to be the most effective prototyping partners, and to be able to understand the abstract idea of designing technologies with low-tech prototyping tools (Druin 1999). Research has also explored the viewpoint of productivity in relation to brainstorming processes with children. The technique of ‘mixing ideas’ is used to foster effective collaboration, especially with young children (ages 4 to 6), during brainstorming design processes. This technique is a framework for merging individual ideas into ‘bigger,’ more collaborative ideas. However, difficulties in collaboration may occur when young children attempt to elaborate on one another's ideas during design workshops. (Guha et al. 2004, 2005.) A child’s stage of development has been suggested to pose a challenge in relation to ‘mixing ideas’ collaboratively (Guha et al. 2004). Instead, children can play key roles as experience design innovators in discovering new and creative ways of using digital artifacts, as has been suggested by investigations into the design of e-learning experiences in educational environments (Garzotto 2008).

Team dynamics among children have been paid special attention in the context of inter-group collaborations. Children themselves have been shown to prefer collaboration between groups, including, for example, looking at the groups’ outputs and sharing visual materials. Comicboarding, as a participatory design method, uses specially created comic books to generate engaging and productive brainstorming sessions with children. However, rather than generating new ideas, children involved in these sessions may incorporate ideas from existing comics in a series. In addition, according to comicboarding techniques, the scope of the generated ideas is limited, since the context and theme of a comicboard are predetermined. (Morajevi et al. 2007.) Thus, this approach can be seen as an example of children reusing, rather than inventing, in brainstorming sessions. Furthermore, imitation has been argued to be a problem in design processes with children, since children may change their designs based on what other children have ideated (Read et al. 2005). However, imitating has also been shown to be a natural behavior that could be leveraged as a resource in design processes (Kuure et al. 2010).
Researchers have also stressed the need to evaluate the quality of the design solutions produced while working with children. For example, it may be important to consider the degree to which children’s design ideas can be applied in design solutions and how their quality can be assessed. (Kelly et al. 2006, Mazzone 2007, Mazzone et al. 2007.) Research has also discussed the factors affecting children’s behaviors in design situations and the possible consequences of these behaviors on the final design (e.g. Mazzone 2007). Furthermore, the outcomes of brainstorming and prototyping as early design methods with children have been compared and evaluated. The number of ideas produced during a design session has been emphasized as essential. Specifically, based on quantitative comparisons, prototyping has been argued to be a better method because it generates more ideas than brainstorming sessions do. (Sluis-Thiescheffler et al. 2007.) Altogether, one can argue that the extant literature seems to be concerned with developing efficient and productive design sessions with children, during which original and independent ideas are produced. Within this line of reasoning, research has also discussed the ideal assembly of intergenerational groups to create the most productive workshops (e.g. Druin et al. 1997, 1999, Druin & Solomon 1996).

**Children’s participation in complex efforts**

In an exploration of children’s participation in large-scale ICT efforts, the literature review conducted by Halkola et al. (2012) revealed that the role of children is not very strong in the reviewed efforts in the research field of IDC. Moreover, in many of the cases, Halkola et al.’s (2012) review showed that children are positioned as users of ICT or viewed as testers and informants (cf. Antle 2003, Druin 2002, Eriksson & Lykke-Olesen 2007, Williams et al. 2003). In summarizing their literature review of children’s participation in more complex cases, Halkola et al. (2012) clarified that children’s role as design partners (cf. Druin 2002) was not fully achieved. It was also revealed in this literature review that, even though the role of children as design partners was considered desirable, their participation was typically limited only to design activities in workshops, and they were not typically involved in the development of ICTs or services. (Halkola et al. 2012.)

In addition to IDC literature, there exists literature on complex efforts involving children within other research disciplines; these works are relevant for this study. Participation has been broadly considered to be individuals’ fundamental right to citizenship, and it advocates for children to be involved in meaningful projects with adults. The understanding of democratic participation and the
confidence and competence to participate can only be acquired gradually through practice; they cannot be taught as abstractions. Without prior exposure to the skills and responsibilities involved in participation, it would be unrealistic to expect children to suddenly become responsible, participating adult citizens. Teaching the principles of democracy in a pedantic way in classrooms – which are, themselves, argued to be models of autocracy – is not a proper approach to achieve children’s learning. Furthermore, concerning this inclusive sense of participation, it has been highlighted that the participation of children and young people necessarily involves considerations of power relations and a struggle for equal rights. Nevertheless, it is important that all young people have the opportunity to learn to participate in programs that directly affect their lives. The Convention on the Rights of the Child has been emphasized as having significant implications for efforts to improve young people’s participation in society and for making clear to all that children are independent subjects with their own rights. Children’s competence in successfully organizing themselves without adult help is clear even from their practices of playing with friends. The motivation for participation grows from children's sense of ownership in relevant projects. Therefore, it is important, at least partially, to allow young people to design project goals themselves; otherwise, they are unlikely to demonstrate the competence they possess. In sum, it has been shown that participation fosters motivation; which fosters competence; which, in turn, fosters motivation for further projects. (Hart 1992.)

There is a significant body of literature on children’s participation within the fields of environmental and urban planning. This literature takes the perspective of empowering children. (e.g. Francis & Lorenzo 2002, Thomas & O’Kane 1998.) In a review of children’s participation in city planning and design, participatory efforts were critically reflected in relation to the various ways for children to participate within these efforts (Francis & Lorenzo 2002). Other work has emphasized the ethics of participatory research with children, arguing that both validity and reliability can be improved by allowing children to take active roles in determining their participation in research efforts and deciding how a subject matter will be approached (Thomas & O’Kane 1998). It has been acknowledged that children’s participation and taking into consideration that children’s interests, concerns, and needs may differ from those of the adults may lead to better decision-making (Ackerman et al. 2003). Furthermore, new participatory models with system and life-world perspectives on the active citizenship and participation of children have been presented in the literature (Van der Veen 2001). Children’s genuine participation has also been advocated in the recent research on ICT design (Iivari
et al. 2015). Furthermore, there is a strong discourse stream advocating children’s participation in an inclusive sense, through their ‘genuine’ (e.g. Chawla & Heft 2002) participation in fields like psychology and sociology. Some relevant studies are discussed next.

The notions of participation and valuation of inclusions of different social groups, such as schoolchildren, were addressed in a study exploring the social shaping of educational technology. In this research project, which was called the OLPC – the Universal Tool for Self-Education, children were not directly involved in the development of educational technologies. Instead, the project identified schoolchildren as a relevant social group in the analysis of strategic and political issues concerning educational technology. Through its analysis, the research aimed to widen existing perspectives on the development and adoption of technologies in education to show that such steps were driven, not by technology, but also by various relevant social groups, including schoolchildren. (Klebl 2008.)

Another study examined the process used in developing and implementing a participatory approach in a children’s ICT project in Barnados, Ireland’s largest national voluntary childcare organization, with over 30 locations around the country (Brady 2007). The aim of this fundamental social inclusion project was to increase and improve access to and usage of ICT by disadvantaged children and their families. The project had an initial duration of one year, commencing with ten-week training sessions that occurred at six sites, including local youth projects and community centers. A community development approach was combined with child participation, such that 33 children (3 to 13 years old) were involved in the project. In the research, a child-centered participatory approach was applied to encourage children’s participation and to motivate parents to get involved. The most meaningful level of participation was to be achieved through the provision of direct training as part of the project. Active participation, shared decision-making, and on-going attendance were encouraged during the arranged learning sessions. The children were allowed to lead their own training, e.g. by choosing games and software or by deciding themes for group projects. Thus, the children participated in self-directed learning, but could ask for assistance if required. The children were also informed about the progress of the course and were asked for written and verbal feedback about their learning and enjoyment. The parents attending the sessions were encouraged to allow their children to take the lead and to refrain from directing them in their choices during these sessions. (Brady 2007.)

Children’s participation as co-researchers was also explored through a children’s participatory action research (PAR) study in Bosnia and Herzegovina
(BiH), which was conducted within the UNICEF initiative on child participation. The project aimed to identify the factors that support and hinder child participation in a BiH context. During the research process, children collaborated with support groups in three BiH municipalities, which were composed of adults who helped the children implement their activities. Each children’s PAR group consisted of approximately 20 children (aged 12 to 14 years old), who collaborated in the selection of the members of their support group. Work within the children’s PAR groups was structured through a variety of child-friendly methods for reflection. The children’s participation was also supported through training on children’s rights, since the research valued the genuine participation of children in the process. During the study’s initiation, children also received information on the methodology of the study and on earlier studies on the topic in the same area. The work of the children’s groups primarily involved issues that the children wished to discuss or address with adults. Subsequent discussions were also based on sets of questions that the children prepared for the discussions’ specific purpose. Each of the children’s groups decided to focus its research on children’s community-level participation, including the initiation of activities by child-led organizations, contact and co-operation with peers in their municipalities, and contact with their municipalities. To ensure on-going communication with their municipalities, the children also had the opportunity to work with contact persons in their municipalities. Based on their needs and interests, the children identified a number of activities that they had found lacking in their communities and through which they wanted to support wider child participation. Finally, based on their experiences in the study, the children identified issues that supported child participation. (Maglajlic 2010.)

The principles of UN Convention on the Rights of the Child have evoked numerous studies on children’s and young people’s participation (Chawla & Heft 2002, Hart 1992). For example, the participation of children and young people in spatial planning and regeneration was explored in a research project conducted in the UK, which also highlighted a wider issue related to children’s rights to participate in decision making (Chawla & Heft 2002). Among similar studies, the level of child participation in spatial planning has been explored, with the aim of understanding the roles that children and young people play in planning, design, and regeneration. Furthermore, such studies have sought to identify the challenges and benefits of placing children at the centre of decision-making processes. (Day et al. 2011.)
Furthermore, in the field of community informatics, children’s participation in efforts aiming to enhance citizen participation have been examined in the context of participatory urban planning and design efforts, as well as efforts related to ICT-mediated participation. The potential of community informatics for participatory planning and design, as well as for ICT-mediated citizen participation, was discussed in a study of the co-design of a shared yard in Helsinki. The public participation case, which was located in the City of Helsinki, involved multiple end users, including young people and children, among other citizens, in the urban planning process through the use of e-participation methods like the Urban Mediator framework. (e.g. Saad-Sulonen & Cabrera 2008, Saad-Sulonen & Horelli 2010.) ICTs were applied as enabling tools in urban planning: for example, the local website and the Urban Mediator were used as platforms and media for the co-creation, sharing, and distribution of information concerning the progress of the co-design of the yard. In addition to these enabling methods, the goal of applying community informatics was to expand the face-to-face participatory process by involving residents and, particularly, adolescents in the strategic use of online tools. The co-design project examined the phases of initiating, planning, and designing the common yard. It identified the different community informatics (CI) tools that acted as enabling tools for the participatory urban planning process and that enhanced the learning processes of the stakeholders. During the project, the youth group learned important skills relevant to digital citizenship by increasing both their participation abilities and their knowledge of ICT use. Consequently, the CI-assisted participatory planning and co-design in this study were viewed as opportunities for young people to learn through different approaches, thus making the adolescents both expert ICT users and active persons and empowering them to become digital citizens. (Saad-Sulonen & Horelli 2010.)

2.2 Research on infrastructures and infrastructuring

Traditionally, IS design begins with uncovering and specifying user needs, which are used to derive technical solutions. The process of starting the development of ISs with user needs is linked to the general assumption that systems to be developed should be or are designed from scratch. It is also related to the idea that traditional IS design methodologies seek to develop closed system through closed project organizations for closed customer organizations within closed time frames. (Hanseth 2010.) Furthermore, traditional IS development projects have been assumed to have defined starting and ending phases, rather than simply being
continual development processes (Orlikowski 1996). This is also the tradition in the research field of software engineering, which assumed that the building of an IS starts with specifying the system, continues with the development of a software product, and ends with the implementation of the product (Pressman 2005). Furthermore, the traditional schools of thought in IS development all share similar pragmatic and especially ontological assumptions, based on a dominant view of, for example, information systems as technical artifacts with social implications (Hirschheim & Klein 1989, Ilivari 1991). In addition, in IS research, the common assumptions about and treatments of information technology are represented through five meta-categories (i.e. the tool view, the proxy view, the ensemble view, the computational view, and the nominal view). However, directing IS research towards broader and deeper interdisciplinary conceptualizations of ICT artifacts, rather than the traditional, taken-for-granted or presuming ICT artifacts is unproblematic once the artifact is built or installed has been proposed. (Orlikowski & Iacono 2001.) Furthermore, recent changes have increased research interest in understanding the more complex efforts involved in IS research. Today’s solutions are significantly different from those of traditional information systems, since they involve integrating numerous systems across organizational and geographical borders (Hanseth 2010) and are connected to and intertwined with complex information infrastructures (Ciborra 2001, Hanseth 1996). Information infrastructures are large and complex systems that involve significant numbers of independent actors, developers, and users (Hanseth 1996).

Traditionally, the concept of infrastructure has been related to large technical and material structures (e.g. water pipes, electricity supply, road networks, and the Internet), which have been understood as background structures or platforms on which the other structures depend (i.e., structures that run ‘underneath’ the actual structures) (Star & Bowker 2002). LTS research, on which we can draw to develop an understanding of infrastructures, has related the concept of infrastructure to the analysis of distributed ISs (Star & Ruhleder 1996). However, the concept of infrastructure has been argued to be insufficient for covering the multidimensionality of use contexts and practices (Star & Ruhleder 1996) or for analyzing large-scale technological systems (Star & Bowker 2002); hence, the concept of an information infrastructure has been recommended.

In the literature, the concept of an information infrastructure has been characterized from different perspectives. Information functionalist accounts in the field of management (Weill & Broadbent 1998) have focused on corporate infrastructures, highlighting the control and management viewpoints. Furthermore,
to understand the socio-technical nature of information infrastructures, the interactionist (e.g. Star & Ruhleder 1996) and actor network theory (ANT) (e.g. Ciborra et al. 2000, Hanseth 1996, 2010, Hanseth & Monteiro 1997, Hanseth et al. 1996, Monteiro 2000, Monteiro & Hanseth 1996) approaches were developed.

Analytically, information infrastructure appears only as a relational property, not as a thing stripped of use (Star & Ruhleder 1996: 113). The notion of infrastructural inversion (Bowker 1994) foregrounds the transparent, background, and historical elements of infrastructures (Star & Ruhleder 1996). This inversion implies a struggle against the tendency of infrastructure to disappear; thus, analyzing infrastructure involves learning to look closely at the technologies and arrangements that foreground the background elements (Star & Bowker 2002). Within the research on the history of science (see e.g. Bowker 1994, Hughes 1987), the history of large-scale systems has been accordingly defined. The common image of infrastructure as a system of substrates, with invisible, background qualities to support other kinds of work, becomes complicated when investigating such large-scale technical systems in situations of infrastructure breakdown (Star 1999). Therefore, infrastructure buildings should also be studied ‘in the making’ (Star & Bowker 2002), with researchers ‘going backstage’ (Star 1999). Furthermore, researchers have suggested analyzing information infrastructure through a kind of Gestalt switch – an ‘infrastructural inversion’ (Bowker 1994) – in order to foreground the truly back-stage elements of work practice, or the ‘boring things’ (Star 2002).

In the following sections, some of the most salient socio-technical definitions of information infrastructures, as well as the concept of infrastructuring, are discussed.

### 2.2.1 Information infrastructures

An information infrastructure is viewed as a socio-technical, ‘fundamentally relational concept, becoming real infrastructure in relation to organized practices’ (Star 1999, Star & Ruhleder 1996, see also Jewett & Kling 1991). There are eight salient features of an infrastructure: embeddedness, transparency, a wide reach or scope, being learned as part of a membership, links with conventions of practice, an embodiment of standards, being built on an installed base, and becoming visible upon breakdown (Star & Ruhleder 1996: 5-6). These are explicated in more detail below:
1. Embeddedness. Infrastructure is “sunk” into, inside of, other structures, social arrangements and technologies.

2. Transparency. Infrastructure is transparent to use, in the sense that it does not have to be reinvented each time or assembled for each task, but invisibly support those tasks.

3. Reach or scope. This may be either spatial or temporal - infrastructure has reach beyond a single event or one-site practice.

4. Learned as part of membership. The taken-for-grantedness of artifacts and organizational arrangements is a sine qua non of membership in a community of practice. Strangers and outsiders encounter infrastructure as a target object to be learned about. New participants acquire a naturalized familiarity with its objects as they become members.

5. Links with conventions of practice. Infrastructure both shapes and is shaped by the conventions of a community of practice, e.g. the way that cycles of day-night work are affected by and affect electrical power rates and needs.

6. Embodiment of standards. Modified by scope and often by conflicting conventions, infrastructure takes on transparency by plugging into other infrastructures and tools in a standardized fashion.

7. Built on an installed base. Infrastructure does not grow de novo; it wrestles with the ‘inertia of the installed base’ and inherits strengths and limitations from that base. Optical fibers run along old railroad lines; new systems are designed for backward compatibility; and failing to account for these constraints may be fatal or distorting to new development processes (Monteiro et al. 1994).

8. Becomes visible upon breakdown. The normally invisible quality of working infrastructure becomes visible when it breaks.

Star and Ruhleder’s (1996) notion of infrastructure stresses the relativity and the socio-technical nature of infrastructures. The definition also implies that the technologies to be developed should be seen in relation to organized practices, as part of the social and organizational structures in which the infrastructure is embedded. The conventions of a community of practice thus shape the information infrastructure. (Star & Ruhleder 1996.) Accordingly, information infrastructure is viewed in relation to working conditions and is never considered in absence of the people who design, maintain, and use it (Star & Bowker 2002). This definition is profoundly based on the perspective of information infrastructures as performative: that is, as partially creating the worlds they subtend (Bowker & Star 1999). A good
information infrastructure is stable enough to allow information to persist over time (Star & Bowker 2002). Still, an infrastructure should also be modifiable on the individual level in terms of ‘tailorability’ (see Nardi, 1993) and on the social level in terms of its ability to respond to emerging social needs. Anticipating and preparing for changes in the design of information infrastructures, as well as the need for information infrastructures to adapt to local needs, have been emphasized (Hanseth et al. 1996, Hanseth & Monteiro 1997). Information infrastructures are evolving as locally tailored technologies become interwoven with the elements of formal information infrastructures. Information infrastructures are, therefore, shaped by the conventions of a community of practice – which, again, have to be adapted to the existing information infrastructures. Thus, these elements are intertwined, ultimately shaping one another. In organizations, locally tailored applications and repositories begin to interweave themselves with formal information infrastructures, creating unique and evolving hybrids. This evolution is facilitated by elements of the formal structures that support the redefinition of local roles and the emergence of communities of practice at the intersection of specific technologies and types of problems. The emergence of a transparently supporting information infrastructure is “organic” and evolving in response to the evolution of communities and the adoption of information infrastructure. Just as information infrastructures must support current conventions in local organizations, they must also be changeable so that they can support evolving practices and use. An information infrastructure emerges when the tension between the local and the global is resolved, and the local practices are afforded by larger-scale technologies, which can then be used in a natural, easily accessible fashion. (Star & Ruhleder 1996.) Not even seemingly large-scale information infrastructures can exist without the support of smaller-scale, local organizations (Bowker & Star 1999).

The Scandinavian school of PD has been considered successful in responding to challenges related to socio-technical design processes and the political and ethical concerns regarding the design of information infrastructures (Star & Bowker 2002). Accordingly, the participatory design of information infrastructures has been examined in other studies using the socio-technical approach (Karasti & Syrjänen 2004, Neumann & Star 1996).

The design of information infrastructures has been characterized as a highly complex, continuous, and evolving process (Hanseth 1996, 2010, Star & Bowker 2002, Star & Ruhleder 1996). Information infrastructures are constantly evolving, and they must be constructed over time on an existing installed base (Hanseth 1996, Star & Ruhleder 1996). This suggests that the development of information
infrastructures should also be seen as a gradual process. An information infrastructure, like other infrastructures, evolves over a long timespan and is never built from scratch. In such a process, the existing infrastructure – the installed base – heavily influences the ways in which new elements can be designed to change and design the existing infrastructure. (Hanseth 1996.) Information infrastructures can be viewed as shared, open, standardized, heterogeneous, and sociotechnical installed base in transformation. This definition emphasizes the quality of information infrastructure as large and complex systems, involving significant numbers of independent actors, developers, and users. (Hanseth 1996, 2010.) This definition also emphasizes the role of the installed base of an infrastructure as a shaping element in its development. The ‘inertia of the installed base’ refers to the influence of the existing base of infrastructure, such that new elements must always be adapted to existing infrastructures. Information infrastructures, actually evolve through the ‘cultivation’ of a shared, open, socio-technical, and heterogeneous installed base (Hanseth 1996, 2010). ANT implies that an existing installed base is an actor in the development process, since it serves as a mediator and a coordinator between the independent, non-technological actors and the development activities (Hanseth 2010). Heterogeneity is one of the fundamental characteristic of information infrastructures, which also challenges developers and has raised concerns regarding information infrastructure management of corporate infrastructures (Ciborra et al. 2000, Hanseth & Lyytinen 2004).

With regard to the aspect of the installed base, notions of alignment and irreversibility (e.g. Callon 1991) have been applied to capture the necessary aspect of information infrastructure standardization, which refers to an infrastructure’s growing resistance to change. To explore the tension between standardization and flexibility in information infrastructures, the notion of irreversibility, which originated from the actor network theory, has been considered to capture this apparent irreversibility – and, to a lesser extent, to explore how changes ripple to other parts. However, this notion does not emphasize the anticipated, alternating, and (to some degree) planned changes of information infrastructure, which occur through alternations between stability and change. The tension between standardization and flexibility in information infrastructures has been found to involve three aspects: infrastructures’ apparent irreversibility, how the inter-connectivity of information infrastructures causes changes in one place ripple to other places, and how standards contingently alternate between stability and change. (Hanseth et al. 1996.)
The design and evolution of information infrastructures have been explored in many empirical studies. In the context of a larger digital library project, for example, the ways in which potential uses, new and old information infrastructures, and large project organizations interact can be examined. During a study of such library projects (i.e. under the Digital Library Initiative (DLI), which is a US government-funded project that created six digital library projects at different universities), social scientists co-developed an information infrastructure by collaborating with users and developers and following the ideas of participatory design. The potential and actual uses of the working prototypes constructed by the developers were studied by conducting usability studies, observing current library users, hosting focus groups with potential users, and engaging in interviews with staff and students. Information infrastructure building was characterized as mediating the demands of multiple groups and making connections between them possible by reaching towards the unknown. That is, while a project should be built on an installed base, its information infrastructure also extends into the unknown. In the studied case, funding agencies, publishers, software developers, librarians, and users each had their own interest in and idea concerning what this unknown would be. Ideally, all of these disparate needs should be met. However, it was discovered during the DLI infrastructure building process that articulating the end product or the meaning of the project as a whole was difficult and that this end product differed for each of the people working on the project. There is a paradox in the building of information infrastructures: while a good working information infrastructure is transparent to use, good participatory design should make all problems of use visible. The end product of information infrastructure projects is ideally invisible, transparent usefulness; thus, the foci of information infrastructure projects are often invisible and difficult to articulate, particularly since there is no common language. Information infrastructure building appears to involve designing linkages among multiple groups and making connections among many people, their world views, and their goals. By examining multidimensionality and multi-culturalism in the building of information infrastructures, it is possible to highlight the importance of creating an evolving project infrastructure capable of allowing the development of multiple information infrastructure metaphors and dreams, as well as standards and protocols. To manage information infrastructure building projects, these various project views are suggested to be linked through shared imageries, or metaphors, which are used as tools. (Neumann & Star 1996.)

Healthcare systems have been examined as ‘work-oriented infrastructures,’ in which users’ roles in the design and implementation such information
infrastructures are essential. Healthcare systems are, and should be, designed and implemented primarily by users based on their actual need and use of the technology. Information infrastructures can, thus, be seen as shared resources for a community. In implementing healthcare information systems, user participation through ‘infrastructure improvement’ is helpful for dealing with possible implementation problems. Considering healthcare systems as ‘work oriented infrastructures’, addresses these systems having the same general characteristics as traditional infrastructures at the same time as they are developed to support specific work tasks and practices; as opposed to the simple and universal services provided by traditional infrastructures: i.e. electric power at a certain voltage, access to telephone networks, water in a pipe et cetera (etc.). Although the different components of information infrastructures are integrated through standardized interfaces, they are open in the sense that there is no strict limit concerning what is included in an information infrastructure and what is not, who can use the information infrastructure, and for which purpose or function. Information infrastructures are heterogeneous, consisting of different kinds of components, both human and technological. (Hanseth & Lundberg 2001.)

Supporting users’ contributions to work infrastructure improvement is vital. While the actors in the processes of such information infrastructure improvement may be professional ICT designers, essentially everyone involved in these processes can be viewed as actors performing deliberate, creative activities designed to create lasting improvement (Pipek & Wulf 2009). In particular, understanding or improving information infrastructures requires integrating the creative activities of the ordinary user. Improvements to work infrastructures as creative activities can be described as designs. With regard to development activities, Pipek and Wulf (2009) suggested the adoption of a broader view, including activities like preparatory design work, preparatory work-development activities, and infrastructural background work, which can take place either in technology development or in the work-development sphere (which has a more strategic nature). Furthermore, through resonance activities that involve observing and communicating aspects of information infrastructure, the social appropriation of certain technology usages can be captured. The concept of use discourse environments is introduced to organize user participation and to support users in negotiating the configurations of the information infrastructures they use. Use discourse environments provide users with communication platforms embedded in their chosen information infrastructures, ultimately providing them the means to easily articulate and visualize issues related to using and configuring their
information infrastructures and to organize these communication and negotiation processes. Use discourse environments also aim to support preparatory work development activities and in situ design activities and to build platforms for resonance activities. (Pipek & Wulf 2009.)

The ongoing and long-term process of designing information infrastructure has been examined in research on the non-professional design of information infrastructures within communities unfolding ‘in the wild’ (Karasti & Baker 2004, 2008, Karasti & Syrjänen 2004). In these cases, community members collectively ‘grow’ their own community information infrastructures without professional intervention (Karasti & Baker 2008). ‘Continuing design’ is suggested to broaden the focus on ‘use’ to one including the long-term perspective required for sustainable collaborative information infrastructure development, thus blurring the boundaries of use, design, implementation, maintenance, and redesign (see also Karasti & Baker 2004, Karasti et al. 2006). ICT development in these cases has been characterized as thoroughly and complexly embedded and interwoven in community activities. In such communities, the blurring of boundaries (i.e. between use, tailoring, maintenance, reuse and design), as well as the attention directed to local, situated everyday technology practices, has led to the perspective of design as a series of artful infrastructure processes that are tentative, open, and flexible. (Karasti & Syrjänen 2004.) The extension of the notion of information infrastructure to more explicitly include the temporal dimension of information infrastructure development has been suggested. Specifically, in the case of the collaborative development of a metadata standard for an ecological research domain, two distinct temporal orientations in information infrastructure development work – ‘project time’ and ‘infrastructure time’ – were identified, suggesting that ‘continuing design’ is a development orientation that recognizes ‘infrastructure time.’ Furthermore, the research emphasizes the need to enrich our understanding of temporality through longer time scales and more diversified temporal hybrids in collaborative information infrastructure development. (Karasti et al. 2010.) Moreover, ‘continuing design’ is suggested to be a development orientation in which the relationship between the short-term and the long-term, which is traditionally seen as a source of tension, is addressed and accounted for from the point of view of ‘infrastructure time,’ thus leading to its incorporation as a foundational design consideration. Even though the ‘project time’-based information infrastructure development efforts can provide stimuli and an impetus for an ‘infrastructure time’-based development orientation, or a ‘continuing design,’ differences in temporal orientations cause problems with regard to participation.
50

(Karasti et al. 2006). These tensions have been exemplified through cases involving developers with ‘project time’ orientations, who are funded for short periods of time, and information managers with ‘infrastructure time’ orientations, who are supported to focus on everyday information management responsibilities (Karasti & Baker 2008b, Karasti et al. 2006).

2.2.2 Infrastructuring

The concept of infrastructuring has been identified in the research literature as appropriate for characterizing the building and evolution of information infrastructures. In this connection, the design of information infrastructures has been seen as tentative, flexible, and open (Star & Bowker 2002). The notion of infrastructuring expands the notion of design with regard to professionalized design activities. The term ‘design,’ as well as the strict separation between design and use, is viewed as problematic, since it focuses on artifacts that should be designed by neglecting the surroundings into which they are placed. Here, infrastructuring is understood as the reconceptualising of one’s own work in the context of existing, potential, or envisioned ICT tools that are natural parts of users’ activities. Large subsets of these activities cannot be delegated to management level or shifted to the next professional design process. (Pipek & Wulf 2009.) Thus, infrastructuring can be perceived as an ongoing design process, leading to the need for designing for infrastructuring, as explained below:

Theoretical challenges suggest moves from technologies as high-tech devices towards more inclusive conceptualizations of thickly interwoven socio-technical infrastructures encompassing mundane technologies and practices and information systems design from one-time technology development towards ongoing processes of infrastructuring. Together these openings challenge us to explore designing for infrastructuring, i.e. how to design for the blurring of borders between use and design, for ongoing changes, ease of maintenance, and tailoring of flexible and adaptable systems. (Karasti and Baker 2004:9.)

The processuality and ongoing character of the activities related to infrastructuring within the extended timespan are essential (Karasti & Syrjänen 2004). Based on existing literature (Karasti & Baker 2008, Pipek & Wulf 2009, Twidale & Floyd 2008), Björgvinsson and colleagues (2010, 2012a) characterized infrastructuring as entangling and intertwining potentially controversial ‘a priori infrastructure
activities’ (i.e. selection, design, development, deployment, and enactment), with ‘everyday design activities in actual use’ (i.e. mediation, interpretation, and articulation) and ‘design-in-use’ activities (i.e. adaptation, appropriation, tailoring, re-design, and maintenance).

The concept of infrastructuring has also been related to the development of large-scale systems that serve a wide range of needs of varied ‘publics’ (Clement et al. 2012). This shift to a new milieu, i.e. open public spaces, rather than spaces within organizations, also entails a reorientation from ‘democracy at work’ to ‘democratic innovation.’ In the same token, there has been a movement away from ‘projecting’ towards the processes and strategies of ‘infrastructuring’. (Björgvinsson et al. 2010, 2012a.) Björgvinsson and colleagues (2012b) explored the concepts of ‘agonistic public spaces,’ ‘thinging,’ and ‘infrastructuring’ in relation to democracy, innovation, and other future-making practices. Agonistic democracy does not presuppose the possibility of consensus or rational conflict resolution. Instead, the hegemony of dominant authority is potentially challenged through manifold forceful but tolerant disputes among passionately engaged publics. The research reflects upon three successive and interconnected collaborative design explorations, analyzing the publics that have been articulated and the agonistic public spaces that have emerged from them. The authors consider infrastructure to be a central issue for modern innovation, demanding extensive collaboration among many stakeholders and over time. (Björgvinsson et al. 2012b.) If infrastructuring is seen as a way to approach social innovation that differs from project-based design approaches, design could move beyond the ‘design project’ and towards a more open-ended, long-term process involving the collaborative innovation of diverse stakeholders. Creation of appropriate innovation environments for social innovation support the building of long-term relationships with stakeholders in order to create networks from which design opportunities can emerge. (Hillgren et al. 2011.)

Furthermore, the public must be understood as a plurality of voices, opinions, and positions: that is, rather than there being one single public, there are a multitude of publics. Furthermore, the concepts of publics and infrastructuring, together, are suggested to form a new perspective that takes into account the different values and relations that exist in these settings. Therefore, infrastructuring can be seen as an ongoing process, which should not be seen as being delimited to a design project phase in the development of a free-standing system. The idea of infrastructuring through design distinguishes among design-for-use, which is centered on useful systems, and design-for-future-use, which is structured to create a fertile ground to
sustain a community of participants. (Le Dantec & De Salvo 2013.) This entails a shift from treating designed systems as fixed products to treating them as ongoing infrastructures, or socio-technical processes that relate different contexts (Le Dantec & De Salvo 2013, Star & Ruhleder 1996). Infrastructuring, then, can be conceptualized as the work of creating socio-technical resources that intentionally enable adoption and appropriation beyond a design’s initial scope – a process that might include participants not present during the initial design (Le Dantec & DiSilvo 2013).

Ehn (2008) distinguishes between two participatory design approaches: traditional, which focuses on participatory design, or design for use before use, and meta-design, which involves designing for design after design. The challenge and object of designing for professional design at project time is the design of potential public things that, through infrastructuring, can become objects of design-in-use; that is, such designs must be left partly open to the participants and the ways in which they may appropriate them. Hence, it is argued that there will be a shift in focus from design aiming at useful products and services to design aiming to create good environments for design at use time. This will, at project time, lead to an occupation with identifying, designing, and supporting social, technical, and spatial infrastructures that are configurable and potentially supportive of future designs in everyday use. Moreover, the shift in focus from involving users in the design process towards seeing every use situation as a potential design situation (i.e. design ‘at project time,’ design ‘at use time,’ and design-in-use after design) suggest a need to view the design process as an infrastructuring of public things. The challenge and object of designing for professional design at project time is the design of potential public things that can become objects of design-in-use through infrastructuring. (Ehn 2008.)

The concept of infrastructuring has also been linked with research on commons (Ostrom 1990). The concept of commons was derived from the economic field of research on managing common-pool resources; however, this concept has recently expanded to encompass the field of knowledge commons (Hess 2012, Hess & Ostrom 2007), which views knowledge as a public good. The linking of the concepts of infrastructuring and commons has been discussed in the context of arts and design research (Anttila et al. 2013). The concept of commons has also been related to new distribution models of films in Sweden to promote the sharing of cultural products and knowledge in the form of cultural commons as a new form of infrastructuring (Björgvinsson 2015).
3 Theoretical and methodological framework

This study relies on a nexus analysis as its theoretical and methodological framework. The first and final problem of a nexus analysis is to discover the social actions and social actors that are crucial in the production of a social issue, bringing about social change. The term ‘social action’ refers to any action taken by an individual with reference to a social network. (Scollon 2001a, Scollon & Scollon 2004.) ‘Nexus analysis’ refers to the mapping of the semiotic cycles of people, discourses, places, and mediational means involved in the social actions under study (Scollon & Scollon 2004: 14). One of the central tasks in a nexus analysis is to examine how:

the broad discourses of our social life are engaged (or not) in the moment-by-moment social actions of social actors in real time activity (Scollon 2001a: 140).

The term ‘discourse’ refers to the ways in which people engage with a broader set of concerns or with each other through face-to-face communication. Discourse analysis may, consequently, concern these different levels of analysis. Simultaneously, nexus analysis may provide a way to unify these levels: the micro-analysis of social interaction and the broader socio-political-cultural analysis of the relationships among social groups and power interests in society. (Scollon & Scollon 2004: 8.) Scollon (2001b) articulated three principles: the principles of social action, communication, and history. This delineation organizes a theory about social action that places a special focus on discourse as a kind of social action, as well as on discourse as a component of social action. These principles maintain that social action occurs at the intersection of three factors: the historical bodies (Nishida 1958) of participants in an action; the interaction order (Goffman 1983), which the participants mutually produce among themselves; and the discourses in place, which enable action or are used by the participants as mediational means in their action (Scollon & Scollon 2004: 153–154). The term ‘historical body,’ which was originally introduced by Nishida (1958), refers to each participant’s individual history, including his or her social identity and role within the action in question. The basis of social action is the habitus (Bordieu 1977, 1990) or historical body (Nishida 1958): “an individual’s accumulated experience of social actions.” Any instance of concrete, real-time social action is simultaneously the production and reproduction of structures of the social world – and, therefore, must be conceptualized in a way that takes these sociocultural histories of our habitus into
account (Bourdieu 1977, 1990). Nexus analysis also makes use of Goffman’s (1983) term ‘interaction order’ to determine the possible social arrangements by which relationships in social interaction can be formed. People behave differently depending, in part, on whether they are acting alone or in consort with other people. All social actions involve implicit or explicit claims to the social groups and positions of participants – as speakers, hearers, and those talked about or in front of. Any action that is taken simultaneously reproduces the identities of prior social actions and negotiates new positions among the participants. (Scollon 2001b.) In most cases, the actions of a social actor are only vaguely purposive and conscious; however, they are almost always multiple and complex (Scollon & Scollon 2003). Scollon and Scollon (2003) saw humans in the physical world as bundles of histories – of language, of discourses, of experiences, and of social and political performances. They also saw humans as juggling multiple social roles and performances, largely unconsciously, and as being the physical bodies that carry these performances out. The term ‘discourses in place’ directs attention to the selection of relevant discourses of the social actions of interest for empirical analysis. This analysis may unify two different aspects of discourse analysis: the micro-analysis of social interaction and the broader, socio-political-cultural analysis. In sum, discourse analysis is a powerful tool for understanding actors’ social lives on the interpersonal, organizational, and institutional levels of social analysis. (Scollon 2001b.)

A nexus analysis proceeds through three cycles. Firstly, the researchers enter the community being researched (i.e. he engages with the nexus of practice) in order to find the social action to be studied and to identify the key actors in this action. Secondly, the researcher explores the action and its actors using various methods and data (i.e. navigating). By participating in the practices, the researcher is also involved in changing them (Scollon & Scollon 2004: 153–154). Such activities combine ethnography, interaction analysis, and other types of qualitative research approaches (Scollon & Scollon 2004).

Within this study, the analytical focus was directed towards micro-actions in an actual infrastructuring effort, while a nexus analysis also led to a recognition of the connectedness of such small-scale development efforts within the wider context of the entire infrastructuring effort (Halkola et al. 2014). A nexus analysis was seen as a fruitful choice for the study of a complex process, since it assumes both (1) that broader social issues are ultimately grounded in the micro-actions of social interaction and (2) that the most mundane of micro-actions form a nexus, through which the largest cycles of social organization and activity circulate (Scollon &
Furthermore, nexus analysis allowed us to extend our perspective from the actual here-and-now situation to wider cycles of discourse on a long-term basis (Iivari et al. 2014). The focus of this study is on the development of the school of the future, a context that encompasses the concept or ideology of a ‘school for the 21st century’, in which children are capable technology users. Thus, the project involves the concrete aim of designing school facilities within a new multipurpose center in a Finnish city (i.e. the Integrated Pilot School), as well as the development of technology-mediated pedagogical practices for even broader use. The process was facilitated through information infrastructure development, involving new solutions in ICT, pedagogy, architecture, and interior design for the city’s entire educational network. The participants in the effort included city educational authorities, various kinds of companies, researchers, and Smart Schools (including their headmasters, teachers, and pupils) selected for the endeavor to experiment with novel technology-mediated pedagogical practices.

On the basis of a broad discourse survey (Scollon & Scollon 2004), which mapped the prominent discourses in the topic, the most important participants (with regard to either institutional status or media representation) were identified from the research data. These participants were selected as the interviewees in this study. Two of the key interviewed persons were project managers (I2 and I3) in the future school development effort, two were the headmasters of Smart Schools (I1 and I5), and one was a city-level development manager (I4). The data include in-depth interviews (see Holstein & Gubrium 1997) with these five ‘key actors’ involved in the development effort, as well as a vast amount of documentation related to the future school concept and the infrastructure-building effort: e.g. background documents, minutes, city web portal pages, project pages, different kinds of reports, newspaper and magazine articles, and materials produced by the schools involved.

The future school development effort was discussed in interviews based on the prepared themes of 1) the background and history of the effort; 2) the nature of the effort; 3) the collaborations among the public, business, and research sectors; 4) the building of the IT infrastructure and the use of technology; and 5) the community aspects and future visions concerning the new town area and multifunction center, including the Integrated Pilot School there. The thematic interview guide was applied flexibly to the interview situation, which was collaborative and discursive in nature. The primary interviewer presented the questions to the interviewee and was in charge of the discussion. However, some other researchers from the research group were also present in the interview situation, and all participants were allowed to participate in the interview discussion, thus making the interview an active
situation. All of the interviews with key participants were recorded. The interviews were then transcribed from the video recordings for discourse analysis. The research data also include interviews with two Smart School teachers (I6 and I7), with whom the following themes were discussed: purchasing processes, acquisitions for schools, and the processes of taking school users (both school children and adults) into account in purchasing. The interviews and the collection of the other data took place as part of the process of ‘engaging’ the nexus of practice, which occurred as the researchers sought out attachment points with the effort’s various social actors. The study then continued by ‘navigating’ the nexus of practice through the analysis of the various circulating discourses. The interviews were studied from a discourse point of view: i.e. we explored how the interviewees made sense of, experienced, and constructed the phenomenon under study (Scollon & Scollon 2004). The notion of subject positions (Davies & Harré 1990) became important in the analysis, particularly with regard to the ways in which the speakers continuously constructed themselves in relation to others. Such positioning may even be directed toward other participants – who, in this case, were referenced in the talk as children.

Additionally, research material was collected from school children during the development of the Integrated Pilot School in collaboration with the city. The starting point for this research intervention, as part of the goal of changing the nexus of practice, was to explore the expectations and development ideas of children related to the Integrated Pilot School as part of the multipurpose community center. Here, the term ‘intervention’ is understood as researchers’ actions causing changes in the community under study, i.e. the nexus of practice. The term ‘intervention’ has not, in itself, typically been used in nexus analysis, as it is a participatory approach; that is, it assumes that the researchers entering a community being researched are, through their participation, also involved in changing the community (e.g. Scollon & Scollon 2004). However, in this research, the term ‘intervention’ has been useful for describing the limited pilot research efforts conducted with children as one stakeholder group of the future school effort. The selected child participants were either living in the housing area or slotted to become pupils of the forthcoming Integrated Pilot School. Ethical aspects of children’s participation in relation to this research were considered, and informed consent was acquired from the parents of the participating children. The research material was gathered through interviews with 24 children and workshops with 15 children. The themes considered in these interventions included home, school, the multipurpose center, community participation, and ICT. These interviews also gave
the researchers the opportunity to discuss themes highlighted by the interviewees, such as their wishes and expectations concerning the Integrated Pilot School. Three workshops were arranged: one with five children, aged 7 to 8, and two with five children each, aged 9 to 12. The design of these workshops was based on the work by Druin et al. (2001) and Scaife et al. (1997). Workshop methods included games, playing (e.g. well-known children’s quiz games with questions about ICT), developing ideas, and planning collaboratively. The children were informed about the new school under construction (i.e. the Integrated Pilot School) and were told about the background ideology and practices of the Future School. The results of this intervention were distributed to the persons responsible at the Integrated Pilot School as feedback and input during development, but also for public use.

Various ethical aspects relating to the children’s participation were considered in relation to this study. First, parents were asked permission for children to participate in the interviews and workshops. Second, the activities involving the children and their elected school representatives were conducted as part of their school work, such that the children’s existing structures allowed participation. The activities were conducted under the supervision of city educational authorities and representatives from the involved schools (e.g. teachers, headmasters). Due to their professional backgrounds, these people were aware of the children’s ages, developmental stages, and related issues.

The analysis proceeded through a succession of data-driven stages. In the first phase, the researchers worked on the data, making initial observations and becoming acquainted with the interviews. Next, an in-depth analysis was conducted for one of the interviews, and the topics discussed by the interviewees and the discourses that emerged over the course of the talk were mapped. In the following phase, the analysis was extended to the rest of the data. Thereafter, the data were examined from the viewpoint of the variety of the participants involved and their participation in the effort. The focus was on both actual practices and circulating discourses. The school children’s participation represented a special focus of the analysis. Later on, the concepts of information infrastructure and infrastructuring were utilized as sensitizing devices for making sense of participation in this complex case. In the final phase, the analysis was elaborated to develop a more detailed study of infrastructuring as social action, during which the analysis was sensitized to the three facets of social action: the historical body, the interaction order, and the discourses in place (Scollon & Scollon 2004). In this phase of the research, the qualitative data analysis software NVivo was applied to analyze the data. Through a nexus analysis, this research illustrates how all of these aspects –
discourses in place emerging here and now, the interaction order among the various stakeholders in the effort, and the historical bodies of the participants – shaped the process of ‘infrastructuring the future school.’ Many of the identified discourses involed legitimizing (i.e. justifying and making acceptable) or infrastructuring, by appealing to either shared values or scientific facts (see e.g. van Leeuwen & Wodak 1999).
4 Empirical results

In this study, various ICT companies were invited to provide ICT for the Smart Schools. In the pilot projects, ICT solution suppliers provided expertise and ICT solutions for use in the schools, and the schools’ architectural, interior, and pedagogical designs co-evolved with these ICT solutions. One global ICT company provided a learning environment platform with a set of hosted collaboration services; communication tools; mobile, desktop, and web-based applications; and data storage capabilities. This virtual learning environment facilitated students’ use of calendars, e-mail, online storage space, instant messaging, and video conferencing, and it was introduced throughout all city schools. Beyond this, each school had differences. The ten Smart Schools selected to participate in the ‘future school programme’ served as pilots for technology use and the renewal of pedagogic practices, while, at the same time, advancing their own locally defined, school-level goals and activities. One of these schools, the Integrated Pilot School, was selected to be equipped with new pedagogical practices and technologies. In one of the Smart Schools, for instance, all teachers and pupils in the third grade were able to use personal laptops. Two classrooms were equipped with electric socket pillars, which enhanced this laptop work. Furthermore, the school’s lobby and corridor were designed and renovated as learning environments, equipped with learning technologies to support experimentation with pedagogical practices. In another Smart School, the school’s hallway and two of the classrooms that opened out onto corridors were renovated and equipped with learning technologies to form a learning environment called ‘the innovative hall.’ The constructed classrooms were designed to support co-teaching practices and the sharing of teacher expertise. In addition, the innovative hall was developed to provide a modifiable ICT learning environment both for the non-formal use of school children and for other users of the school building. The innovative hall includes a stage for student presentations, performances, and project work exhibitions. The stage is equipped with technologies like a projector and a wall-mounted projection board. There is also space under the stage for technologies and sound reproduction equipment. The interior of the hall was designed to be modifiable, including seats that can be used for school meetings, performances, school hour breaks, and other users of the building. (Background documentation.)

Moreover, the Integrated Pilot School is boldly argued to be designed to support school work reform. The building of the Integrated Pilot School was based on the winning school architectural plan from an architectural competition. All of
the interior design solutions were designed to be flexibly movable to support emerging learning needs. The starting points for the architectural plan were a sense of communality, co-operation, and flexibility. The Integrated Pilot School was particularly planned in response to the needs of the 21st century learner in terms of both the spaces and the level of equipment. In the Integrated Pilot School, the starting points for interior design are ‘learning cells’, which include both home classrooms and shared classrooms. The classroom spaces are planned to be capable of opening flexibly in order to enable collaborative teaching. With regard to the technology infrastructure, in addition to whiteboards, the classroom teaching equipment includes smart boards with the ability to download information as presented in the classroom computer. Furthermore, the classroom ICT solutions enable teachers to send learning materials, including notes made on the smart board, to pupils via e-mail. Teachers utilize laptops, video projectors, and video cameras in their teaching. Moreover, the first and second graders work in groups with shared desktops, and all teachers and pupils from the third grade up have their own personal laptops. Finally, not only the school’s learning environments, but also its school yard, have been equipped with modern ICT. (Background documentation.)

4.1 Article II: Children’s participation in the ICT development for the future school effort

In the following, children’s participation in the ICT development for the future school effort will be presented from the perspective of the children’s positions (Davies & Harré 1990), as assigned to them in the interview talk. In the interviews, the speakers constructed themselves in relation to other participants. From these constantly changing constructs of the speakers’ own subject positions (Davies & Harré 1990) in relation to other participants within the effort, certain subject positions (Davies & Harré 1990) were directed towards children.

4.1.1 Child as an innovative user

In the interview talks, first, the children were observed as users (cf. Druin 2002) of learning technologies (e.g. through working with their laptops and utilizing different programs in learning events). In relation to children’s participation in ICT development, one interviewee from the subject position of an actor in a global network characterized the children’s positions as technology users and content
producers in a study project closely connected to a global company and its products as follows:

So children’s participation in this phase has rather come through contents and projects, like when they have started doing something, let’s say the water project they were working on. As a group they (...) I was following it and I have later been able to see through video how it was completed (...) in that phase they just got a project topic and started as a group to consider how it would be done and what they would need and who would be involved and so on. (I1)

In the following, the same interviewee speaking from a grassroots-level practitioner’s subject position described children’s positions as innovative users in the ICT development – i.e. their role in developing new uses for existing technologies at the school:

And where this kind of participation has come up sort of naturally (...) how these school children, third-fourth-graders, how they, in a way, take part in using these devices and programs by sort of inventing most ingenious shortcuts (...) Children cut corners wherever they can, and they often find quite new applications. (I1)

The same interviewee described the involved technologies as both participatory and capable of offering school children opportunities to find novel and more personal methods of use in a learning context, compared to more conventional ways of learning:

So, that’s how this new technology actually could be said to be participatory in itself, if it is compared with the old kind, based on a textbook. The book was there, you were able to participate by underlining something, but now you can, in principle, create totally new working methods with it. (I1)

4.1.2 Child as an informant

This analysis also shed light on how children were positioned as informants (cf. Druin 2002) in relation to the pilot development projects for the Smart School learning environments. These projects typically dealt with the physical environment and the construction of a technological infrastructure. One example of such a project was mentioned by an interviewee from a grassroots-level practitioner’s subject position. This interviewee described how school children
commented on house plans and plans for technological solutions to be developed for the learning environment in practice:

But then, for example, when this plan for the future school classroom was being done with the architect’s office for the upper concourse, the pupils were here involved so that I had once, we were at the office, so we had pupils with us and this completed plan was taken to them for comments: what they think it looked like and what benefits it would have. (I1)

The elected representatives of the school children had been given the opportunity to contribute to the ICT development process also in another pilot project. The interviewee, in the position of a change agent, describes children’s positions as informants in meetings:

Well in these joint meetings when the premises have been planned and put into practice, at regular intervals, the representatives of the student body, representatives of children and representatives of pupils have been present in planning meetings. (I2)

The representatives of the school children were also asked for comments concerning the selection of specific technical equipment, as follows:

So we have now asked them about and discussed right this, what sort of technology it is that they want. For example, about game consoles and musical equipment and if there could, should be, for example, a docking station like for [mobile device] where you can stick your own phone and watch those snowboarding videos or your own music videos when there is spare time. This is the kind of stuff there’s been. (I2)

The children’s role of continued participation as informants in technology development also emerged in the data. Speaking from a grassroots-level practitioner position, one interviewee envisioned the children's participation through the children's comments on their everyday use experiences of the learning technologies in relation to their school activities:

What I think myself about participation and this kind of school activity in general; this is kind of continuous development. In that sense you could imagine that you could study participation also while you go, even though technology is already there, but also hear children's views, like what works, what could be different. (I1)
Another interviewee, speaking from the position of a future school promoter, envisioned that children utilizing learning environments could contribute even more extensively to the development of their learning environments:

“I think that children’s role there [in planning] has been fairly minimal now that you consider the kind of technology that is coming there and has been chosen, when those children are all around [city]. But perhaps, when the activities are launched, I think they will have a great role when we start building those learning environments, electronic learning environments and so on. How those will be utilized then, so that is where their role is certainly great.” (I3)

Furthermore, in the context of advocating learner-centred product development, children were envisioned to participate even during the very early phases of technology development:

“Talking about learner-centred technology development, as I said about [product development project], we involve users early and above all so that they can have an impact on applications or products or services.” (I4)

### 4.1.3 Child as a tester

In the data, children’s participation as testers (cf. Druin 2002) was related to user evaluations of the learning solutions produced during the learner-centered product development. The school children participated in evaluations of a mobile learning environment and a learning game, as an interviewee from the subject position of an advocate of learner-centered product development discussed:

“So this kind of usability information, now [mobile environment] is just one example there, another good example of what’s been done well here [learning game], it was used with fifth-graders, niners and pupils in upper secondary grades. And during that half-hour gaming session one saw that it was meaningful, pupils were smiling, everybody had a good time and stuff had been learnt.” (I4)

Furthermore, technologies for the future school were envisioned to be developed in co-operation with companies and other actors. In this vision, with regard to the learner-centered product development process, children were considered to participate as testers of technological solutions and related practices in their school environments:
Products, concepts are tested together with companies and with researchers and with practitioners, i.e. teachers, and through them also pupils and the pupils’ parents become involved in this product development collaboration. Those well-working concepts are tested, which provides feedback and that's how good practices (...) faster or faster than before (...) can become transferred as part of practice. (14)

4.1.4 Moving towards genuine participation

In sum, children were seen as users, testers, and informants in the technology development process (cf. Druin 2002); however, more interestingly, the role of the school in enabling children’s genuine (Hart 1992) participation was prevalent. This perspective was presented by an interviewee from the subject position of a strategist advocating children’s participation. According to this interviewee, children’s genuine participation could be realized in schools by allowing children to take part in constructing their schools and planning the activities held there. However, school children’s participation as it is today could be improved, as follows: “Children are more involved as active agents in the school environment (...) However, pupils are still too seldom taken along in school planning although there’s been a great deal of progress.” (15).

The interviewee stressed the responsibility of adults to enable children to participate in the planning and decision-making of school activities. Below, the interviewee addresses the system perspective (Van der Veen 2001) of children’s participation:

We have spoken a lot with headmasters already that in schools they must now involve the pupils in school work so that you don’t only have a program committee that organizes parties or sells sweets during breaks, but the pupils could genuinely have an influence, always having certain items on the agenda in the teachers’ meeting, items for the student body, there could be pupils present at the teachers’ meeting. (15)

It is important to note that the schools already had structures that allowed or enabled children’s participation:

If I think about community feeling and opportunities for influencing, I think it could well be done with children and young people (...) We do have well-functioning organizations, student bodies at each school, and there is really
favourable ground, because it is them, who are thinking about what it is that the student body could assume more responsibility over, while it is always offered the kind of role that it is nothing more than a party organizer, celebrator.

(15)

From the life-world perspective (Van der Veen 2001), the interviewee envisioned further that school children's participation could be made even more genuine. In the interviewee’s vision of child-initiated participation, children were allowed to equally influence the setting for their participation: “If you consider how one could promote children’s and young people's participation one must ask children and young people about it. So the activity is done sort of directly with those children and young people.” (15).

Even the view of allowing children’s participation in nearly all school-related actions was emphasized: “If you consider where pupils cannot participate in the school there isn’t much where they can’t.” (15).

Furthermore, the interviewee highlighted the role of the school in responding to challenges that the children were likely to confront in the society of the future. To foster the children’s future participation in society, school activities had been designed to foster their participation skills in practice: “From the third grade to the final year in the upper secondary school, all the groups have gone through training on inclusion where there’s been grouping, and people have got acquainted with municipal decision-making and some meeting practices.” (15).

The interviewee also mentioned a local citizen meeting event as an example of children’s active participation as citizens: “This citizen meeting, absolutely great presentations were given. They were definitely not something they would have prepared in advance, because these children and young people presented really many questions.” (15).

4.2 Article III: Participation of various actors in information infrastructure building – a nexus analysis of discourses and concrete participatory practices

Next, the future school effort will be discussed with a focus on its participative aspect. In order to conceptualize the future school effort, the concept of information infrastructure (Star & Ruhleder 1996) has been applied. Discourses justifying and characterizing participation in the effort are identified, as are users’ concrete participation activities.
4.2.1 Discourses for challenging but also appreciating the installed base

An installed base influences all future developments, since information infrastructures always inherit strengths and limitations from their installed base (Star & Ruhleder 1996). On the level of discourses, the various actors in the future school effort were invited to challenge the installed base. At the same time, the existing installed base was positioned as highly valuable, such that all development efforts were encouraged to appreciate and rely on it. Discourses from both of these perspectives contributed to the justification of the broad participation of different actors in the effort. The invitation to challenge the installed base became salient in the discourses describing the vision of challenging the ‘traditional school’ in order to construct the future school concept and information infrastructure. The installed base of the traditional school’s information infrastructure was envisioned to be modernized through the process of constructing the future school with 21st-century pedagogical practices and learning environments:

It is a kind of ideology which involves a consideration of the learning environments of the 21st century, learning in the 21st century. How should the traditional school boat be updated, then, for us to reach these, to offer our future experts the skills of the 21st century in the changing world? (I2)

The renewal of technology has been legitimized through children’s technology skills in their everyday lives, “as children already have at home their computers and mobile phones” (I1). In the interviews, a discourse on all-embracing renewal seemed to arise as necessary for the change towards the future school, involving experts of various kinds: on teacherhood, leadership, physical learning environments, technology: “And there is change (...) We want to develop the whole or in other words develop all of it as a whole (...) On all levels something has been done – teacherhood, leadership, physical learning environment, infrastructure, technologies.” (I2).

However, the effort did not only involve arguing for challenging the installed base. The educational authorities interviewed also emphasized the importance of local actors’ knowledge of local settings, referring to the installed base:

We [in the educational section] believe in the constructivist view in this development work, too – that it has to be created within the organization, and there you have the knowledge once you find it and share it, and that is where the best practices emerge. (I4)
The schools profiled their own strategies for their educational development projects and for the adoption of learning technologies based on their schools’ installed base. This working approach was positioned as necessary, while the method of building a model and then transferring it to different contexts was perceived as ‘old-fashioned’:

*This model is good for starting to support the schools in this way, so that they get started from their own profiles and utilize their own practices and search for those strengths, take them forward. But the transferability of such models is sort of old fashioned thinking.* (I4)

In order to facilitate an appreciation of the installed base of each school, broad school participation was required.

**4.2.2 Discourses for equality, sustainability, continuity and cutting edge solutions**

Information infrastructures have temporal and spatial reaches beyond single events or one-site practices (Star & Ruhleder 1996). In this case, discourses arguing for even further extensions of the temporal and spatial reach of the information infrastructure became evident. Discourses arguing for equality, sustainability, continuity and cutting edge solutions call for extending the reach of this information infrastructure, justifying broad participation of various actors.

The discourse on equality has necessarily broadened the development of a single school – the Integrated Pilot School – to also concern other city schools. The proposed Integrated Pilot School was originally planned to serve as a model for other schools, such that new learning technologies with new practices would be developed in the Integrated Pilot School and then disseminated to other schools. However, the discourse on equality in education, which argue for providing equal opportunities to all schools – at least in the city, if not even nationally – e.g. through ensuring similar levels of technological equipment, has become prevalent: “*At that stage in the educational administration it was wisely determined that we cannot be building one innovative school, one elitist school in a way that other schools envy.*” (I2) Another interviewee stated: “*They [learning technologies] just simply are so much better when compared to this former range of equipment and there is already so much well-functioning, usable material that should be available in every single school in Finland, in every municipality.*” (I1). Thus, the broad participation of schools and collaboration on a national level became necessary.
The continuity of the development effort from the viewpoint of the school children also played an important role. For instance, in one of the Smart Schools, collaborations with other local schools to ensure continuity for the children was considered necessary:

*Our contribution with respect to this age group ends on grade six, but it is not the aim to finish with that age group – but [instead to] create ground for them for continuation so that they could then, until the end of comprehensive school, utilize or use the methods that we have here launched. Enrich and develop them.*

(I1)

The pedagogical practices employed through the new learning technologies have been envisioned to be further applied in elementary schools, with younger children. The emphasis on continuity again justifies the inclusion of numerous schools in the effort, at least through cooperative work with other schools.

The discourse on sustainability was also evident in the data. This discourse emerged, for example, in the talk of an interviewee representing educational authorities, who emphasized the importance of continuing the practices and technological solutions developed during the school pilot projects: “*One should find such sustainable solutions that can be funded even if the economic situation deteriorated a little.*” (I4). The development of the information infrastructure for the city’s educational network began with the application of funding for separate pilot projects; however, the development work has since been considered part of the continuous development of the city’s educational administration.

An emphasis on world-class, up-to-date, and cutting-edge solutions was also evident in the interviews, with interviewees highlighting the need for “*technologies as innovative as possible*” (I2) or arguing that “*we have tried to be a few years ahead*” (I3). The process of staying up to date with technology has been characterized even as “*soaring*” (I1) or taking “*quantum leaps*” (I4) in technology development. This can be connected with the project’s collaborations with global networks, in relation to which a vision of “*bringing the technological solutions all over the world*” (I2) was boldly expressed. The educational authorities and project managers had, indeed, collaborated with pedagogical and technology experts within the global network in order to define the general action goals for constructing the city’s future school. Via this network, participants were able to visit other schools and share experiences internationally:
We have together met other schools, developer schools, internationally and there has been teacher-, headmaster-, (...) and then also the representatives from [the global company]. (...) There have been international experts related to learning (...), at every stage we have figured out the experts, who have given their own input to this work. (13)

The need for cutting-edge solutions has justified the inclusion of global companies and schools in the city’s information infrastructure-building effort.

4.2.3 Concrete participatory practices among teachers and pupils

Star and Ruhleder’s (1996) notion of information infrastructure stresses its socio-technical nature, which implies that information infrastructures are always shaped by the conventions of communities of practice. These communities of practice, in turn, must be adapted to existing information infrastructures (Star & Ruhleder 1996). In the process of constructing the future school, the adopted technological solutions and pedagogical practices became entwined, since pedagogic practices were developed alongside technology in order to meet the needs of the future school’s learning objectives. A learner-centred view was raised as a basis for shaping pedagogical practices. Supporting the personal objectives of each learner and viewing learning in a wider context have been noted as foundational activities for the use and, occasionally, even the selection of learning technologies. The learning environments were constructed using technological solutions (e.g. technology providing remote connections and access to information) capable of supporting both collaborative practices and personalized teaching. The concrete participatory practices shaping the technology and pedagogical practices were carried out primarily by teachers, with pupils also playing a role.

The teachers’ contributions to developing the pedagogical practices linked with information infrastructures were crucial. The teachers contributed both within the general framework of the curriculum and in more specific projects. The teachers also developed e-learning materials for the digital learning environments in order to support the use of technological solutions and new models of learning. “I make quite a lot of material [for the digital learning environment] myself (...), which then modifies according to the pupils. So that there is this individual consideration and different kinds of learners.” (16). Different styles of learning were supported through a variety of e-learning materials, with the use of personal laptops
exemplifying the enhanced adaptation of pedagogical practices for personalized learning:

*We have personal PCs in use; it does change the nature of teaching a lot. We can consider the pupils so that (...) [those who are] not able to read that much can listen, and (...) [those] who cannot write that much can produce speech with the computer. *(I6)*

Interior design and technology developments have required teachers’ pedagogical expertise to ground the developed practices to the local Smart School settings. Both educational officials and teachers have participated in the development projects as pedagogical experts:

*We may have a more pedagogic orientation to what should be done with the equipment. There is no point in ordering a huge amount of screens if we have nothing to present. (...) I am involved in our development effort of [the] innovation hall, in a kind of group of developer teachers. (...) We have, together in this group, designed everything, made these activity descriptions and planned what is needed for different activities, possibly. (...) We have made very detailed descriptions of all the situations, learning situations, and some other school-related situations. *(I7)*

The Smart Schools have created new practices to support teachers’ development work. Instead of requiring detailed pre-planning, such development has been characterized as evolving:

*We haven’t had and we cannot have had such a detailed preliminary model [for] how we will proceed, but we have sort of created it all the time in the course of the process (...) We have, for example, started creating this co-teaching system, so that when the goal is to get teaching and learning more learner-centered, and also utilize these teacher strengths – strengthen the teachers’ wellbeing, innovation – those models that have sort of been developed during the process. *(I1)*

Within the pilot projects, the teachers have combined their pedagogical knowledge with their understandings of local school practices and organizational settings:

*The whole age group was in one large group: two teachers, who, between themselves, very freely started planning how to do things with that grade, how to divide them into groups, in which subjects etc. (...) The aim was to start
working at the beginning of the autumn term, so that each one [pupil in the large group] would have had a personal TabletPC of his/her own. (I1)

The teachers also planned to further develop the exploitation of best practices from pilot projects:

Well, this framework is there. This teacher pair continues with this age group, and they further elaborate and develop that co-teaching model and the synergy of several teachers. Now, we’ll start to emphasize it more in the curriculum, which means that there are two teachers, and they have the liberty of arranging the work in class. Now, we’ll get rid of rigid subject division (...) We are aiming at this kind of holistic, wider learning. (I1)

The teachers’ participation and more general awareness of the objectives of the future school were promoted through in-service education. In one of the Smart Schools, weekly meetings with mentors were arranged to support teachers’ development work:

And every week, these teachers of the third-graders at that time, plus the teacher-pair who would start the following year in the same way, and these mentor teachers, they were meeting on a weekly basis, discussing where we are and what sorts of plans there are, what kinds of partners can be engaged. (I1)

Occasionally, teachers’ resources were reserved for planning the work and education of their colleagues:

They will take one day to plan something like – depends on how much they need, for three days or as long as a week – when they then discuss the fifth and the sixth grades and wishes concerning the upper grades, and also the training of the other teaching staff – share the positive experiences about technology use. (I1)

Furthermore, teachers from the other Smart Schools were invited to participate in the arranged planning and training days: “We offer it [training given by the developer teachers] also to other teachers in the future school project so that they could come along and pick from there whatever they wish.” (I1). However, involving teachers necessitated additional arrangements for their participation and could possibly also expose trade union tensions, as explained by a representative of the local educational official:
We could have a more flexible time plan for teachers, but, unfortunately, this has not been successful (...) The teachers' union is quite strong, and they don’t necessarily always see that, even if teachers themselves wish the work could be developed. (I4)

Pupils were also involved as participants in the information infrastructure building for the future school (see also Halkola et al. 2012). As users and learners, the pilot projects offered possibilities for experimental and collaborative learning in modernized learning environments supported by technological solutions. In addition, the pupils acted as informants and testers (cf. Druin 2002) of the learning technologies. As informants, elected representatives of the schoolchildren were asked in meetings for comments concerning architectural plans and plans for the selection of specific learning technologies. School children also participated as testers in user evaluations of the learning technologies produced through the learner-centered product development. Furthermore, school children have evaluated a proposed mobile learning environment and a proposed learning game.

In addition to being related to technology development, children’s participation emerged as a topic in the discourses on the school’s role in enabling children’s more genuine participation (Hart 1992). The headmaster of the new Integrated Pilot School envisioned school children’s participation as a subject to be learned through the construction process of the new school:

Then, there’s one topic that has kept appearing – engaging children, children and young people, in the design of the activities and in starting the activities themselves. We should also have practiced that in designing this house, for example, and considering the things that should be purchased (furniture, for example), so that is actually what we have sort of practiced and thought about. (I5)

The school already contained structures to enable children’s participation, as emphasized by a representative of the local educational official. Therefore, children's genuine participation could be realized by allowing them to take part in constructing their school and planning the activities in there more comprehensively.

Table 2 summarizes the characteristics of participation of various actors in information infrastructure building.
Table 2. Characterizing the participation of various actors in information infrastructure-building.

<table>
<thead>
<tr>
<th>Actors</th>
<th>Discourses on challenging and appreciating the installed base</th>
<th>Discourses on equality, continuity, sustainability, and cutting-edge solutions</th>
<th>Concrete participatory practices shaping technology and practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils</td>
<td>Offered motivation to challenge the traditional school as apt technology users</td>
<td>Offered motivation to ensure continuity and equality</td>
<td>Mainly related to shaping technologies, minor influence</td>
</tr>
<tr>
<td>Teachers</td>
<td>Invited to challenge the traditional school as inevitably relying on local settings</td>
<td>Needed to ensure continuity</td>
<td>Developing pedagogical practices</td>
</tr>
<tr>
<td>Headmasters</td>
<td>Invited to challenge the traditional school as inevitably relying on local settings</td>
<td>Needed to ensure equality, continuity, and sustainability</td>
<td>Developing enabling practices (teachers’ work arrangements)</td>
</tr>
<tr>
<td>Companies</td>
<td>Invited to challenge the traditional school</td>
<td>Needed to ensure cutting-edge solutions</td>
<td>Providing technology, experimenting with it in local settings</td>
</tr>
<tr>
<td>Researchers</td>
<td>Invited to challenge the traditional school</td>
<td>Needed to ensure cutting-edge solutions</td>
<td>Developing pedagogical and enabling practices (teacher education, impact assessment)</td>
</tr>
<tr>
<td>Educational administration</td>
<td>Invited to challenge the traditional school, but also to appreciate local settings</td>
<td>Needed to ensure sustainability and equality</td>
<td>Developing enabling practices (funding, in-service education, school-company cooperation)</td>
</tr>
<tr>
<td>Global network</td>
<td>Invited to challenge the traditional school as inevitably relying on local settings</td>
<td>Needed to ensure cutting-edge solutions</td>
<td>Providing technology, developing pedagogical practices</td>
</tr>
</tbody>
</table>

4.3 Paper IV: Infrastructuring involving both adults and children

To characterize the building and evolution of information infrastructures, the concept of infrastructuring was applied (Björgvinsson et al. 2010, 2012a, Karasti 2014, Karasti & Baker 2008, Pipek & Wulf 2009, Star & Bowker 2002). Infrastructuring in this research is viewed broadly as reconceptualising one’s own
work in the context of existing, potential, or envisioned ICT tools – a natural part of every user’s activities (Pipek & Wulf 2009). However, the need for ‘design for use before use,’ which takes place ‘at project time,’ and not only ‘design-in-use,’ which takes place after design in the design project (i.e. “infrastructuring”) (Ehn 2008) has been acknowledged. Design-in-use includes various kinds of activities, such as tailoring, configuring, appropriating, and negotiating (Pipek & Wulf 2009). Moreover, this research acknowledges both technological and work-related developments (Pipek & Wulf 2009). Furthermore, this study interprets design to concern social, technical and spatial aspects (Ehn 2008), including the design of ‘surroundings’ (Pipek & Wulf 2009). Additionally, this research acknowledges resonance activities that involve observing and communicating aspects of infrastructure, through which activities related to the appropriation of certain technology usage can be captured (Pipek & Wulf 2009). Inspired by Pipek and Wulf (2009), the study emphasizes the importance of users articulating, negotiating, and visualizing issues that permeate the use and configuration of infrastructure. Finally, in this effort, interesting observations relating to designing for design after design (Ehn 2008) emerged in the sense that some parties create solutions to support such infrastructuring activities.

As mentioned, in this case, various ICT companies were invited to provide ICT for the Smart Schools. In the pilot projects, the ICT solution suppliers provided expertise and ICT solutions for the schools’ use. The following sections will illustrate the infrastructuring that took place following the emergence of these ICT solutions, which were ‘designed for use before use’ (Ehn 2008). Next, the multitude of actors and the objects of design involved are presented.

4.3.1 Architectural and interior design solutions intertwined with ICT

As has already become evident, in the studied case, there was considerable focus on architectural and interior design as aspects of infrastructuring. The development efforts varied from the building of new schools to the renovation of old schools – and furthermore, to the work of schools aiming to create new models of operation. Interior design and architecture were considered essential in constructing innovative learning environments for the Smart Schools. To provide a basis for the development plans, architectural evaluations of the Smart Schools were conducted as described in the following: “We have carried out architectural rounds, reviews, based on which these architectural designs of the environment of the 21st century have been created.” (I2). Interior solution suppliers also tested the furnishings in
the Smart School learning environments: "With the interior solution suppliers, we have test-furnished these target places (...) and we think together what [the] kind of (...) furniture of the future learning environments will be." (I2).

The architectural and interior design aspects of the information infrastructure were planned in co-operation with various kinds of educational experts. These professional spatial designs were designed to support the new pedagogical models, while leaving open possibilities for design-in-use through flexible solutions and responsiveness to emerging needs. In addition, resonance activities allowing teachers and pupils to articulate and negotiate issues around the infrastructure were organized. The Smart School teachers and pupils were invited to comment on the architectural plans and the selection of the learning technologies during arranged meetings:

For example, when this plan for the future school classroom was being done with the architect's office for the upper concourse, (...) we had pupils with us [in the architect's office], and this completed plan was taken to them for comments: what they think it looked like and what benefits it would have. (I1)

Well, in these joint meetings, when the premises have been planned and put into practice, at regular intervals, the representatives of the student council, representatives of children, and representatives of pupils have been present in planning meetings. (I2)

Teachers also invited student councils into the process: "I am the guiding teacher of the student council and took the pupils into the process. (...) We have, together with pupils, considered what we needed and how the equipment will be used." (I7) Another interviewee stated:

Where these architectural rounds have been made, children have also been listened to. And [the school] has especially excelled in this; there is a well-functioning student council, so that, there, these drawings and plans have become commented [on] by the student council (...) Of course the teacher was there as a guide (...) Very good comments were gained. (I2)

4.3.2 Pedagogical solutions intertwined with ICT

The planned infrastructural aspects of the architectural, interior design, and ICT solutions required teachers’ pedagogical expertise to ground the solutions in local
Smart Schools’ settings and practices. Educational officials and, especially, some Smart School teachers participated in development projects as pedagogical experts:

_We maybe have a more pedagogic orientation to what should be done with the equipment. There is no point in ordering here a huge number of screens if we have nothing to present. (…) First of all, we [three teachers] have, together in this group, designed everything, made these activity descriptions, and planned what is needed for these different activities possible. We approach it so that we have made very detailed descriptions of all the situations, learning situations, and some other school related situations._ (I7)

The Future School ideology positions the learner as an active agent and a researcher who participates in collaborative knowledge creation in a group. ICT applications are expected to create new innovative possibilities to support collaborative learning and knowledge building. (Background documentation.) The constructed learning environments for the Smart Schools were planned to support the utilization of ICT solutions, thus enabling both collaborative and learner-centered work practices, as well as personalized teaching. The teachers also developed learner-centered, personalized e-learning materials for the digital learning environments: “_I make quite a lot of material myself (…), which is then modified according to the pupils, so that there is this individual consideration of different kinds of learners._” (I6).

The use of e-learning materials with personal laptops was also seen to support learner-centered, personalized learning:

_We have these personal PCs in use; it indeed changes the nature of teaching a lot. We can consider the pupils so that the one who is not capable of reading that much can listen, and the one who cannot write that much can produce speech with the computer and enliven the stories this way. (…) We have a lot of boys who did not like to write at all. They refused to write stories, but as it happens, with a computer, it is a bit nicer to write, illustrate, and create voice._ (I6)

Pupils’ collaborative knowledge creation has also been supported through pedagogical practices intertwined with ICT: “_Now we have laptops here, and we can simultaneously share the same work in real-time. (…) It is this kind of sharing._” (I6)

Furthermore, the constructed learning environments with ICT solutions have been envisioned to support new pedagogical models, such as simultaneous teaching (co-teaching) and cross-grade teaching (no division into classes according to age
group). Smart School teachers were encouraged to develop and experiment with the pedagogical models and practices intertwined with ICT:

*The whole age group was in one large group – two teachers, who, between themselves, very freely started planning how to do things with that grade, how to divide them into groups, in which subjects etc. (...) The aim was to start working at the beginning of the autumn term, so that each [pupil] would have had a personal TabletPC of his/her own. (I1)*

Instead of involving detailed pre-planning, the development work was designed to be flexible – characterized as evolving – in order to enable adjustments: “We haven’t had, and we cannot have had, such a detailed preliminary model of how we will proceed, but we have sort of created it in the course of the process.” (I1). The available ICT solutions clearly shaped the teachers’ pedagogical practices. Moreover, the teachers actively appropriated ICT, intertwining it with their pedagogical practices, and experienced teachers helped their pupils appropriate ICT as part of their schoolwork. The schools and teachers also exercised influence over the technologies adopted. For instance, concerning the new virtual learning environment adopted in the city, an exception was made in one of the Smart Schools, which was allowed to continue using the current virtual learning environment because it contained personalized e-learning materials designed for use with the laptops. In some cases, the development projects were even initiated by the schools’ teachers and pupils:

*The whole idea has actually been initiated by us [teachers and pupils] originally, so that this is not such an external idea (...) There is a long continuation of this; we have wanted continuously to improve the level of technology and the learning environment also. (I7)*

The development projects have also made these facilities available for other teachers not directly participating in the development projects. Thus, the pilot projects were recognized as “*bringing good to the entire school*” (I6). Within their communities, the teachers shared their experiences of experimental teaching with ICT. This encouraged other teachers to appropriate new, ICT-based pedagogical practices as well: “*The use of these technologies is possible, and interest and willingness has now awakened among other teachers to change [their] teaching methods and expertise.*” (I6). In addition, the teachers’ participation in and more general awareness of the objectives of the Future School program were promoted
through in-service education. In one of the Smart Schools, weekly meetings with mentors were arranged to support teachers’ appropriation of ICT in their teaching:

*And every week, the teachers of the third-graders at that time, plus the teacher-pair who would start the following year, as well as the mentor teachers, were meeting, (...) discussing where we are and what sorts of plans there are, and what kinds of partners can be engaged.* (I1)

Occasionally, teachers’ resources were reserved for planning work or for educating their colleagues to support the use of ICT in their local organizations:

*They will take one day to plan (...) – depends on how much they need, for three days or as long as a week – when they then discuss the fifth and the sixth grades and wishes concerning the upper grades, and also the training of the other teaching staff, and they share positive experiences about technology use.* (I1)

Furthermore, teachers from other Smart Schools were invited to participate in the arranged planning and training days to facilitate the sharing of technology use experiences: *“We offer it [training] also to other teachers in the Future School project so that they can come along and pick from there whatever they wish.”* (I1)

### 4.3.3 Enabling solutions supporting infrastructuring activities

In the Smart Schools, new practices were created to enable teachers’ development work. The co-teaching system and its associated development model are examples of enabling solutions created to support and enhance teachers’ development work in relation to the appropriation of ICT solutions to support pedagogical practices:

*We have, for example, started creating this co-teaching system, so that when the goal is to get teaching and learning more learner-centered and also utilize these teacher strengths, we also strengthen the teachers’ wellbeing and innovation. Those models have sort of been developed during the process.* (I1)

The importance of involving teachers in the development work was deemed to be very important in the overall effort.

*This [is what] our solution aims at, as there are two teachers who support each other during the whole work day. We have noticed that, when the teachers do not toil alone, their innovativeness increases, [their] coping improves, and [their] work motivation increases.* (I1)
Teachers’ participation in development work can, however, necessitate additional arrangements, potentially also exposing tensions from the direction of trade unions, as explained by a representative of a local educational official:

*We could have a more flexible time plan for teachers, but, unfortunately, this has not been successful (...) The teachers’ union is quite strong, and they don’t necessarily always see that, even teachers themselves wish the work could be developed.* *(I4)*

The Future School effort has also created an environment in which a network of the Smart Schools and some companies seek to collaborate and develop solutions further than what can be considered enabling solutions in this infrastructuring effort. For the companies invited to provide ICT solutions and experiments, the Smart Schools have offered living-lab environments for product development and experimentation in local settings: “*We have trialed it already with these ten Smart Schools by offering these schools as a kind of development platform for new products, new technologies, and new experiments.*” *(I2)*. Favorable possibilities for the development work have been arranged by initiating tripartite cooperation efforts for the joint development work with the public, research, and business sectors:

*On all levels, something has been done – the teaching profession, leadership, physical learning environment, infrastructure, technologies. Within all the sectors, something has been done, and company collaboration and research collaboration has been launched ... With these ten Smart Schools, we have been busy and have advanced them; their ideas have been enriched and supported. And these projects have then been established around it.* *(I2)*

Novel recruiting and competence management processes, as well as ICT support, have also been developed collaboratively with a global company. Such processes were developed for the purpose of identifying necessary competencies for teachers in the Future School, as well as the optimal ideology and best practices for pedagogy, ICT use, and the recruitment teachers:

*Regarding the teaching profession, we have cooperated with [a global company] and some other agents. We have thought of these competencies of the teachers of the Future School and this whole curve of competence management. We have figured out ready-made models (...) on how to change*
the recruitment system so that it is based on the personnel plan of the school and on competencies of the teachers of the Future School. (12)

Here, related to competence management, they [a global company] have had a strong role. (...) A tool has been prepared for Finnish headmasters (...) There has been an actual tool prepared for recruitment. There are videos for help on how to carry out the recruitment process, as well as related issues, such as what questions to address, etc. (15)

Therefore, this aspect involves both an ICT solution and new practices for recruiting teachers suitable for the Future School (which will be equipped with innovative ICT and pedagogical practices) and for managing the competencies of such teachers.

4.3.4 Children’s role

Pupils were also involved in the infrastructuring activity. Children’s appropriation of technologies in learning was supported by their teachers. Primarily, pupils were involved as users of the introduced learning solutions. The innovativeness of children as ‘designers-in-use’ has already been acknowledged in the studied case: that is, as users of the learning technologies, pupils created new innovative practices. Moreover, as mentioned, the pupils acted as informants and testers of learning environments for the Smart Schools. Elected representatives of the school children were asked in meetings for comments concerning both the architectural plans and the plans for the selection of specific learning technologies. Children’s participation as testers was related to their user evaluations of the learning technologies produced. The pupils participated in evaluations of a proposed mobile learning environment and learning game.

Additionally, in the interviews and workshop sessions we organized, the children were given opportunities to innovate regarding the ways in which ICT could be used at school and in learning. Most of the children’s ideas were mundane, reflecting ICT tools already in use by school-aged children. For example, the availability of computer games for learning at school was commonly suggested: “One goes for example to learning pages.” (Pupil boy, 1st grader). Furthermore, the Internet was frequently addressed: “You can view on the Internet, some stuff from there ... or, if you get, for example environmental information tasks, or environmental stuff there from the computer.” (Pupil boy, 1st grader). The use of computers and the Internet was considered in the context of supporting assignments
at school and with homework: “…for looking for information, for example, from Wikipedia.” (Pupil boy, 6th grader). “Maybe so that, from [the computer], one could get information on what needs to be done.” (Pupil boy, 1st grader). Computer use was also viewed as helpful in preparations for exams: “One could do such things that will be helpful, like for forthcoming exams, one could make notes with [a computer], if it is much quicker. Your hand gets tired when you do like this [writing with pen].” (Pupil girl, 5th grader). Mobile phones were also considered in terms of their usability for learning: “If there were awfully difficult calculations in math, for that one could use [mobile phones]…” (Pupil boy, 3rd grader). Furthermore, the ability to take pictures with mobile phones was considered useful:

> It would be nice, if one reads some helping text or something like that, one could remember how it was. For example, in math, take a picture with the mobile phone. Then, at home, one can look at it and think with the help of it, if one takes a picture of a math exercise – a picture of what was taught at school.

(Pupil girl, 5th grader)

More creative ideas inspired by technology-mediated learning and less influenced by prevailing pedagogical practices were also identified from the data. In one vision, the ability to use computers was viewed as inspiring and helpful in the process of ‘spreading out’: “It would be nice to go somewhere, not necessarily in the class, but (…) spreading a bit out – not necessarily needing to stay at [one’s] own classroom, but one could be, for example, in the lobby [of the school].” (Pupil girl, 5th grader). Moreover, highly imaginary and playful visions emerged, such as: “...a robot that would make the homework, so you would not need to do the homework” (Pupil girl, 2nd grader), and a “kind of flash drive which can be placed in the ear, and there you can download any material” (Pupil girl, 3rd grader). Similarly, it was suggested that: “There could be a handy phone that comes to you when someone calls” (Pupil boy, 1st grader) or “...a television the size of [a] class wall” (Pupil boy, 2nd grader). The children also acted as idea creators of pedagogical practices. For example, pupils suggested “learning through play” (Pupil boy, 1st grader) and learner-centered teaching in music: “one could start, from the grade three, to practice playing guitar” (Pupil boy, 3rd grader). In a workshop with 9- to 12-year-olds, when the children were asked about the potential of multi-subject teaching, they identified some interesting combination possibilities in the fields of history and religion (“Jesus adventures in some history book”), French and domestic science (“...studying French during domestic science – we could make all the French meals”), and gym and music (“...you move according to the music”).
In the table below (table 3), a summary characterizing infrastructuring in the school context is given.

**Table 3. Characterizing infrastructuring in the school context.**

<table>
<thead>
<tr>
<th>Design</th>
<th>Actors involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical – ICT</td>
<td>Companies: designing for use before use</td>
</tr>
<tr>
<td></td>
<td>Teachers: design-in-use (appropriation), resonance activities</td>
</tr>
<tr>
<td></td>
<td>Pupils: design-in-use (appropriation), resonance activities</td>
</tr>
<tr>
<td>Social – Pedagogical</td>
<td>Teachers: designing for use before use, design-in-use, resonance activities</td>
</tr>
<tr>
<td></td>
<td>Pupils: design-in-use (appropriation), resonance activities</td>
</tr>
<tr>
<td>Spatial – Architecture and interior</td>
<td>Companies: designing for use before use</td>
</tr>
<tr>
<td></td>
<td>Teachers: design-in-use (appropriation), resonance activities</td>
</tr>
<tr>
<td></td>
<td>Pupils: design-in-use (appropriation), resonance activities</td>
</tr>
<tr>
<td>Enabling</td>
<td>Headmasters: designing for design-in-use</td>
</tr>
<tr>
<td></td>
<td>Educational authorities: designing for design-in-use</td>
</tr>
<tr>
<td></td>
<td>Companies: designing for use before use</td>
</tr>
</tbody>
</table>

4.4 **Paper V: Interaction orders and historical bodies influencing children’s participation**

As mentioned above, the school children were involved in the infrastructuring effort; however, they were mainly involved as users, informants, and testers (cf. Druin 2002) of the learning technologies adopted in their schools. Because of this situation, a research intervention was organized to allow children to express their expectations and their development ideas. Thus, the children were involved in the infrastructuring process and generated ideas for a learning environment for the multipurpose community center in which the Integrated Pilot School was to be located. In the analysis of the research material gathered from this research intervention, the nexus analytic concepts of interaction order and historical body (Scollon & Scollon 2001) were utilized as methodological tools.

From the historical body point of view, this study repeats, once again the influence of children’s familiarity with current technologies. In this respect, the suggestions provided by the participating children were significantly influenced by
their personal media experiences and practices. The children ideated familiar learning games and the use of the Internet, laptops, and mobile phones. The use of computer games in learning the alphabet and the process of getting guidance on school assignments from learning games were suggested: “We have [at home], for example, jack-of-all-trades and secret speller pages.” (Pupil boy, 1st grader). Certain variations were also suggested, such as using game consoles with learning games – “for some game consoles one can get learning games” (Pupil boy, 3rd grader) – and for using the Internet – “With PlayStation 3, one can go to Internet.” (Pupil boy, 4th grader). Children’s habits and hobbies were also clearly reflected in their suggestions concerning the use of the Internet for information retrieval, which were connected with children’s interests in environmental studies or taking care of pets” “From there, you can view the Internet, some stuff from there ... or, if you get, for example, environmental information tasks or environmental stuff there from the computer...” (Pupil boy, 1st grader). “Or then some pet care stuff, those could be checked.” (Pupil boy, 1st grader).

In relation to the interaction order, adults were perceived as important ‘others.’ Interestingly, the children expressed some hesitation in discussing their ideas of technology use in learning: “I don’t know if it is allowed, but a mobile phone could be used as a calculator, although that should not be allowed to be used in exams.” (Pupil boy, 1st grader). However, when use of these suggested technologies in learning practices was approved by adults, they were considered helpful, especially in the context of math exercises. Children’s hesitance concerning technology use also emerged in the children’s views of utilizing mobile phones equipped with GPSs in orientation. As a solution for limiting the use of technologies, one pupil suggested that “it would be possible to do so that mobile phone could be used in every other orientation lesson and a map in every other.” (Pupil girl, 5th grader). Similar views on the use of GPS technology were also brought up: “[The] using of a map would help in the development of the sense of direction. Old traditions would be forgotten, if the usage of a map and a compass would ... not be studied.” (Pupil boy, 3rd grader).

It was also interesting to observe that some children seemed to echo the voices of adults when expressing a need for children to be supervised and controlled by adults while using ICT. In one example, the frequent use of computers at school was considered to affect learning – and if not controlled, “one would not learn anything.” (Pupil girl, 5th grader). Similarly, it was suggested that: “Nowadays, computers are used too much at school. (...) It would be nice if there were one
computer lesson a week when one is allowed to do homework with a computer.” (Pupil girl, 5th grader).

On the other hand, adults’ attitudes may also encourage children to contribute. Teacher’s positive attitudes towards using technologies in learning seemed to be reflected in the children’s suggestions for using ICT in learning; they also seemed to mediate the children’s contributions. For example, the combination of video projectors and touch screens, which was introduced by a teacher, was envisioned as useful in other contexts, such as when doing homework:

...if the teacher showed us something that the teacher has done for us, we could go to the homework page ... and so we could, for example, test if we have learned the issue. We just could go to the homework page, press [the touch screen] and see what happens there. (Pupil girl, 5th grader)

Parental influence also became visible in this study from another angle: the contributions of the children to suggestions on technology use in learning sometimes seemed to reflect the habits and hobbies of their parents. For example, learning music at school using a computer was suggested: “My father plays the guitar at home, and he is saving it to the computer and composes, so it is a good idea in principle [to use a computer in teaching music].” (Pupil girl, 5th grader). On the other hand, this significant relationship between children and their parents is also significantly related to the children’s historical bodies. This means that the children’s contributions, though based on their current knowledge of the potential of ICT – i.e. their historical body – were also significantly related to their prevailing social networks and everyday interactions.

4.5 Paper VI: Infrastructuring as social action

In the following, infrastructuring as social action is discussed. This analysis has been sensitized to the three facets of social action: discourses in place (i.e. those emerging here and now), the interaction order among the various stakeholders in the effort, and the historical bodies of the participants, all of which shape infrastructuring.
4.5.1 Discourses in place: infrastructuring taking shape

“Child’s best” as an undeniable motivation for legitimating infrastructuring

The future school infrastructuring effort involved the construction of learning environments using ICT intertwined with novel pedagogical practices. The discourse emphasizing the “child’s best” legitimized the construction of these modernized learning environments using ICT. The future school effort was considered vital for providing technology and media skills to learners of the 21st century, since these learners are the future experts and members of our changing society: “Basic education must provide pupils with basic skills for utilizing technology and so forth to cope with society today and in the future.” (I4). Hence, many of the study’s participants considered the construction of learning environments with up-to-date learning technologies to be important for preparing pupils for their future roles in a technologically advanced society: “The school, if anything, should use that good, most up-to-date technology and teach these growing young people to cope with it.” (I1). On the other hand, the changing everyday lives and improved technological skills of school children were regarded by many of the participants in the study to be challenges to students’ learning and pedagogical practices at school. New learning practices involving the use of ICT were suggested to increase school children’s motivation to learn. As children’s ability to utilize technologies has expanded their potential sites for learning in leisure time, the mismatch between current learning practices at school and students’ lives beyond the school day has become an argument motivating new learning practices: “It is a challenge for us to consider how they [free-time interests] could be drawn on in the school world – it is extremely important for the [children’s] motivation level.” (I5).

The future school infrastructuring also involved renewing the school’s operational models and the connections between these models and ICT solutions. Addressing the concerns of the “child’s best” demanded the development of collaborative practices among school personnel. As a new operational model, the different administrative sectors were to be represented collaboratively in order to create a community basis for a child’s entire school day:

*Developing the whole school day—that’s how this community aspect, so those people present in the child’s daily life would collaborate (...) now we are talking about comprehensive basic education, so all of those who are involved*
The renewals also addressed the teachers’ work practices. The future school effort actively experimented with new collaborative models among teachers, which involved the increased use of ICT in teaching. Along with these changes, teachers’ responsibility for developing pedagogical practices related to a “child’s best” was increasingly addressed. The need to encourage teachers to become developers of their own work was addressed, as follows: “how you make the teachers committed to development work and, well, see how development is part of every teacher’s work, so that everyone has the responsibility for developing that work for the best of the child and youth.” (I4). Furthermore, in addition to ICT appropriation, learning practices were reorganized according to the altered interaction order between teachers and their pupils: that is, it was agreed that students should become more responsible for their own learning. In this context, teachers should act as supporters of pupils’ learning by providing novel pedagogical arrangements. The children’s roles as future members of society were also considered during the interviews, and the desire for more active positions for school children became evident. The discourse on the “child’s best” addressed the idea of involving children as planners of their own school activities: “Then, I must say that involving children and young people in planning activities – and after the launch, the action itself – has been highlighted more.” (I5). Furthermore, the institutional role to be played by the school in terms of operating more collaboratively for the “child’s best” concerned, not only the school personnel, but also the school itself as an active actor in society: “The school really isn’t another island in the middle of society, but it embraces everyone that is there in the day of the child or youth.” (I5). Collaborative operational models to extend to school–home communications between teachers and parents were also developed: “One of the most important issues is to get collaboration with homes going so well that parents and caregivers have a strong presence in the everyday life of the school.” (I4).

Equality in education and its role in legitimating infrastructuring

One shared tradition of the Finnish school system is its strong legislative basis for equality in primary school education. This topic was discussed in the interviews in relation to the ICT infrastructuring of the educational network: “Compulsory education: there, children, young people should have equal opportunities for
receiving instruction in technology and media skills in different subjects.” (I4). However, issues related to positioning city schools differently in relation to one another were highlighted. To maintain the equality aspect of Finnish primary school education, accounts were given to suggest that the specific role of the Integrated Pilot School could serve as a model for the other schools. Thus, the Integrated Pilot School would act as a pilot for constructing learning environments and experimenting with related operational and pedagogical models. Furthermore, the pilot school would act as a pioneer by creating models involving ICT use. This approach would also benefit other schools in the city, or even on the national level. As one of the interviewees expressed:

We will have quite a strong leading position when teaching is developed, even on a national level within Finland. We would be able to bring in new approaches and models – I even believe that we will eventually be spearheads [in the city]. (I5)

Some of the interviewees expressed a concern regarding the provision of equal opportunities to all city schools (e.g. through similar levels of technological equipment). This concern was conveyed through narratives concerning the development of the broader educational network in applying the new models: “At that stage in the educational administration, it was wisely determined that we cannot be building one innovative school, one elitist school, in a way that other schools envy.” (I2). Hence, the discourse for ensuring consistent education equality was related to expanding best practices of ICT appropriation across the entire educational network: “Maybe from the point of view of other schools, the development may be unfair – like all eggs are put in one basket. So, we launched this Smart School project then.” (I4); “Best practices have already been shared with these ten pilot schools.” (I2).

As a counterpoint to the building of new, highly ICT-equipped school buildings, there were also suggestions to promote equality by budgeting resources for the modernization of old school buildings and their learning technologies. In other words, some participants suggested drawing on existing resources rather than building new schools: “One should definitely invest in how these [old school buildings can be] (...) made as functional as possible. Now, the usual excuse is having to wait until there’s a new building.” (I1). Concern for equality in education arose because, while there were financial resources allocated to technological infrastructuring for the selected Smart School development projects, there were
hardly any concrete action plans or funds for developing the other schools within the educational network:

And the remaining 50 schools then – it is something to deal with still – something should be done about it little by little. So, we know that there are about 50 schools that are quietly waiting, while these ten plus one schools [eleven schools] are enjoying additional resources and get support. [They are] expecting to get support eventually, these schools. (I2)

Despite these budgeting concerns, some of the interviewees’ accounts suggested that there is actually an equal technological budgeting basis for all of the city’s schools, in accordance with the relevant legislation for regulating budgeting and purchasing in the school domain. In an attempt to create consensus or reduce criticism, accounts were given to ensure that the learning technologies for city schools of the city were always purchased through similar processes. The negotiation procedures and collaborative decision-making processes that occurred within the planning group of the Integrated Pilot School were also considered: “We were planning this school in the working group, so it has been built according to the same funding principles as our other schools. So, there is no more investment in technology there.” (I4).

The discourse on equality in education occurring during the interviews was also constructed for the purpose of toning down the “wild plans” (I4) concerning technological renewals. Such “wild plans” (I4) were not considered to be realizable in all schools: “The wildest plans, at some point, have kind of remained in the background, also because of lacking resources. And then, there hasn't been enough evidence for them having such great significance for the developing work.” (I4).

On the other hand, the traditional school was discussed in parallel with the cutting-edge learning technologies of the future school. These technologies were also suggested to be made available equally across the city’s schools, and even to become available nationally:

They [learning technologies] just simply are so much better when compared to this former range of equipment, and there is already so much well-functioning, usable material that should be available in every single school in Finland, in every municipality. (I1)
Accountability to taxpayers and society shaping infrastructuring

The shared tradition of the Finnish public school system was expressed throughout this discourse. Accountability to taxpayers, and especially to the parents of the pupils, was considered very important, as were the assumed expectations of those taxpayers: “I am sure there will be some challenge coming from the taxpayers, the parents. It somehow seems that the expectations today from parents, for example, towards the school grow all the time.” (15). The legislation and administrative agreements controlled by the National Board of Education were described as significantly hampering school infrastructuring. Specifically, they were described as normative and restrictive, and many interviewees recommended challenging these restrictions:

(…) how we could challenge the traditional way to build and plan schools – it followed largely the norms set by the National Board of Education, all class sizes and furniture, and you wouldn’t get the state subsidy if you didn’t follow them. (I2)

However, external and city funding within the future school effort enabled altered building and infrastructuring processes.

Furthermore, advancing possibilities for the public use of the various facilities, including schools’ ICT features, also became a prevalent topic in the discourse regarding accountability to the taxpayers: “Another challenge is communal use. How would the technology and premises acquired with taxpayers’ money serve the surrounding community?” (I2). The topic of communal use was one manifestation of this discourse. The new multipurpose center with the Integrated Pilot School was described through a metaphor, in which the school was the center of a village2 and was envisioned as becoming an active meeting place for local residents:

I see communality in that case as some kind of communal use and its cultivation. A little bit like the old village school used to be the center of the village, where everything happened – let’s now move it into the city-like environment, the suburb. (I2)

This model was used to legitimize the high costs of the infrastructuring effort. Accountability to taxpayers was compared to traditional school planning based on

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2 The Finnish compulsory education system and the school network are based on the principle of schools being located close to the pupils: in rural areas almost every village has had its own school. Traditionally such village schools have functioned as hubs for community activities. (Kalaoja et al. 2009).
stakeholders’ needs and activities and those of the local inhabitants: “Especially in smaller municipalities, these kinds of building projects being planned are like the most expensive projects in the village history, which means that they would really be planned for those needs and those activities” (I3). Drawing on this vision, which was shared by the key actors in this research effort, the multipurpose center and its integrated school were viewed as an environment available to multiple actors and activities: “…as a kind of active, virile, and functional environment, full of action and with actors of different ages and many kinds of participants.” (I3).

**Etiquette for tripartite collaboration intermingled with infrastructuring**

Tripartite collaboration with the public, research, and business sectors was arranged within the future school effort to facilitate joint development work. Infrastructuring within the pilot projects included ICT solution suppliers providing expertise and solutions to the Smart Schools. Architectural, interior, and pedagogical solutions also co-evolved with the ICT solutions. The shared tradition focused on educational officials as the controllers of public procurement and of collaborations with commercial companies, following the legislative-based tradition of the Finnish school system: “Traditionally, the companies have been kept out of the school domain.” (I3). The tripartite collaboration model, however, challenges this tradition. Within this model, the school became a more interactive actor in the community, rather than a “solitary island in society”. This model also required company collaboration. External experts were invited to define the ground rules for company collaborations and to define the principles of etiquette, clear agreements, and contractual bases:

> We have the capacity and the mindset for the time when business life, working life creates new innovations for the market, so we would boldly test them for our purposes, too. The way it happens, then, we need to think about it then so that it would be based on a contract. (I5)

Thus, a consultant report for recommendations for company collaborations within the school environment was created: “About the etiquette [ground rules] and this, we have the first consultant’s report.” (I3). This discourse not only foregrounded the need for neutrality in company collaborations, but also ensured that decision power remained on the side of the school: “You just need to establish an etiquette that preserves the neutrality, the independence of the school.” (I1). Even though involving new actors changed the interaction order of the school domain, the
legislation-based tradition of neutrality in company collaborations remained unaltered. Subsequently, concerns regarding keeping infrastructuring decision power or control on the side of the school during development efforts were highlighted.

**Scientific evidence for legitimating, if not guiding, infrastructuring**

Legitimation based on scientific results was considered to advance the development efforts of the schools. The discourse called for scientific evidence for evaluating the advantages of technology-mediated learning, as follows:

> We would also hope that, if an environment or technology of this kind is embedded somewhere, there would be research on it ... could study the effectiveness and if it improves learning results, motivation, the teacher’s well-being at work, and so on, and if we are going to the right direction through these solutions ... that's what we would like to see more. (I2)

During this process, the importance of scientifically verified guidance was brought into the foreground: “Last year, when we saw that we were starting to take off and fly high, if we had been guided more tightly...” (I1). Research was also considered to provide a wider perspective: “Someone who would have sort of a research approach and bigger visions.” (I1). In addition to supporting the development efforts, this discourse addressed the importance of scientific evidence in the form of reports, as well as the importance of different kinds of measurable variables. These were discussed as “traditional comparative measurements” (I1), and they were valuable in applications for funding. The interviewees highlighted the importance of scientific evidence in creating convincing communications for educational or funding authorities: “for applying for funding, [scientific] collaboration brings credibility” (I3); “It would always be easier to convince all the partners if there was a clear measurement or evidence or knowledge gathered in some way. I mean, now we have to lean on our own explanation.” (I1). The discourse stressed, however, that scientific collaboration was to play a supportive role, while the power to make decisions and the control over the development efforts would remain with the schools themselves: “[Scientific evidence] would be more in a kind of supportive role in advancing our community process.” (I5). On the other hand, somewhat conflicting viewpoints on research partners’ contributions were also revealed. From this perspective, research partners were positioned as providing scientifically verified models and state-of-the-art research results: “So, tell us what the latest research results are, what is available, and what
we know about these things. Come and study what we have here: that is how the good result emerges, then.” (12).

Leadership discourse on financial and human resources

All of the interviewees worked in managerial positions – a trend that became clear in the data. First, the interviewees attempted to cater to all of the city’s schools. They all sought to create sustainable solutions for learning environments that would be achievable for all of the schools within the city’s educational network: “We can pilot approaches that don’t then work in practice, so if you cannot offer it to everyone ... You should, however, find sustainable solutions.” (I4). It seemed that the future school infrastructuring was a result of the schools being able to find their own profiles within the development effort:

We [in the educational sector] believe in the constructivist view in this development work, too – that it has to be created within the organization, and there you have the knowledge, once you find it and share it, and that is where the best practices emerge. (I4)

The method of building a model and then transferring it to different contexts was seen as “old-fashioned” by some of the interviewees:

This model is good for how to start supporting the schools in this way, so that they started with their own profiles and utilize their own practices and search for those strengths – take them forward. But the transferability of such models is sort of old-fashioned thinking. (I4)

On the other hand, attempts to transfer schools using ready-built models derived from global network experts also emerged:

In that way, we started thinking about our own work, and how development projects that were planned behind the future school ideology ... how they are put into practice, and that’s when this Smart School network or piloting group of ten smart schools was established. (I4)

Such a model for infrastructuring positions schools merely as executing actors of expert-driven development projects.

Human resource management also emerged from this discourse as a potential issue of the future school infrastructuring effort. Within the pilot schools, some enthusiastic teachers were already actively creating new pedagogical practices
using ICT. In this context, the renewal of teacherhood was promoted in relation to the use of best practices, and teachers’ work practices were expected to become more collaborative: “Teachers must work more together, as, moving away from the lesson and class division system, teachers have to deal with the whole of the school and the pupil and share their work.” (I1). Attitudes, knowledge, and skills, as well as possible in-service training, were used to support teachers in the appropriation of ICT into their pedagogical practices:

The greatest challenge, if we think about this scenario of the future, is that, increasingly, everything is going on in the networks, and technology is utilized. So, the fact is that, even today, we do have teachers who don’t and who haven’t perhaps even woken up to the reality that this kind of expertise is needed, so we really need a lot of in-service training. So, in-service training is one big issue. (I4)

 Attempts to advance teachers’ collaboration by concretely changing the divisions among administrative sectors were also discussed. The requirements for collaborations among personnel were considered significant, even in the recruiting of teachers:

Teachers … one must be able to work in a way somewhat different than before, and that has been taken into account in recruiting staff – that there are teachers who are ready to have a wider look at the ideology of teaching … We need to be successful in recruitment to get people who are ready to experiment with things in a slightly different manner. (I5)

These concerns have led to changes in personnel policies, as well as the processes and tools for recruiting and competence management:

Regarding the teaching profession, we have cooperated with <company> and some other agents. We have thought of these competencies of the teachers of the future school and this whole curve of competence management. We have figured out ready-made models … on how to change the recruitment system so that it is based on the personnel plan of the school and on competencies of the teachers of the future school. (I2)

Here, related to competence management, they [the global company] have had a strong role … A tool has been prepared for Finnish headmasters … there has been an actual tool prepared for recruitment. (I5)
In addition to available human resources, leadership discourses were circulating around financial resources enhancing infrastructuring: “Now, for instance, if I didn’t have this additional funding, I wouldn’t be able to order such equipment for <school> in this phase.” (I1) External funding gave the schools more decision power to select new technologies and advance through new purchasing procedures. With external funding, it also became possible to allocate resources to teachers to facilitate independent planning and more collaborative work practices:

External funding makes these changes possible. It has always been possible to free the teachers for a planning day, and the costs for substitutes have been covered from project money, so they have been able to think and plan themselves … I am prepared, they may even need a week when they will be free from other work. (I1)

Furthermore, to facilitate collaborative operational models, it became clear that even the current payroll systems required renewal to enable collaboration among teachers: “The teachers’ salary system must change so that we can move in this direction. Now that it is based on teaching hours, it necessarily binds you to the wrong direction.” (I1). The leadership discourse on financial resources also foregrounded the need for change agency to promote the infrastructuring of the future school:

Now that there’s a recession, there’s a kind of mental depression going on quite clearly, and such a mental atmosphere is not where we build the school of the future, that’s quite certain … Despite the diminishing amount of euros, we should keep up a drive – a drive for development there. A positive tone. (I5)

Promotional innovation discourse

The discourse on promotional innovation was also highly pervasive throughout the interviews. This discourse can be characterized by the following extract from the data, which highlights the extensive scope of the future school infrastructuring effort:

On all levels, something has been done—the teaching profession, leadership, physical learning environment, infrastructure, technologies. Within all the sectors something has been done and company collaboration and research collaboration has been launched. (I2)
The learning environments were to be constructed with learning technologies designed to be “as innovative as possible” (I3). The ICT solution supplies were “bringing the technological solutions all over the world” (I2), offering the most world-class, up-to-date, and cutting-edge solutions, as captured by this quote: “we have tried to be a few years ahead” (I3). The process of constructing the future school was even characterized as one of “soaring” (I1) or taking “quantum leaps” (I4) in ICT development. The presence of experts from the global network was also emphasized:

In <school>, this “inno lounge” [innovative lounge] learning environment—or, in practice, it means that <the name of an actor> and I have the possibility of bringing forth the ideas of the future school and what we have learnt when we have been travelling around the world in different schools: the possibility to make those thoughts transparent in <school>, make partly transparent or bring in innovative furniture, actually top-class educational technology. (I3)

Some of the city’s schools were positioned as leaders in the future school effort, while others were characterized as learners, following the new operational models: “If we think about the degree of innovativeness, maybe <pilot school 1> and <pilot school 2> are those crown jewels there.” (I2) The interaction order among the schools within the city’s educational network was suggested through the promotional talk, which positioned the Integrated Pilot School as a pioneer and model for the other schools to follow. Through this discourse, the relevance of global experts for infrastructuring was also highlighted. References to external funding sources also echoed the presence of additional participants relevant to the infrastructuring effort.

4.5.2 Historical bodies and interaction orders entangled in infrastructuring

Existing research has already acknowledged the complexity involved in infrastructuring. In our study, the nexus analysis provided theoretical tools for better understanding this complexity, including the multiple voices and contributions of the various actors involved in the infrastructuring. In the following, these components are discussed in more detail.
Historical body: studying the historical aspect inherent to infrastructuring

Existing research has acknowledged the inherited historical aspect of information infrastructures by defining the installed base as one of their shaping features (e.g. Hanseth 1996, 2010, Star & Ruhleder 1996). “The inertia of the installed base” ensures the continued relevance of the existing infrastructure base, to which new elements always have to be adapted (Star & Ruhleder 1996). Regarding infrastructuring within PD research, calls have emerged for considering the temporal aspect of infrastructuring in more depth, including a shift from a longitudinal future orientation to one accounting for the past temporal horizon, e.g. through dealing with shared histories, existing ISs, and the installed base (Karasti 2014).

In our empirical analysis, the concept of a historical body referred to an individual’s accumulated experiences of social actions. This concept was valuable for sensitizing the analysis to the infrastructuring’s past temporal horizon. The experiences and local practices inherent to the historical bodies of the local actors were appreciated as human resources. The schools actively profiled their development efforts, and the teachers’ pedagogical expertise was valued for its use in grounding the solutions of the local Smart Schools’ settings and practices. The historical bodies of the teachers, which arose from their understandings of their local school practices, were valued – and, hence, shaped the infrastructuring. However, it became obvious that, in addition to local school practices, the everyday practices of the children – especially in relation to their technology use – also shaped the infrastructuring. The school children’s technology and media skills were embedded in their historical bodies and served as motivations for the infrastructuring effort. The renewal of teaching and learning practices, as well as the construction of technology-rich learning environments, was justified by the school children’s altered everyday lives and improved technological skills.

Traditionally, the Finnish school system has been based strongly on legislation, which has shaped its infrastructuring. One important aspect of the Finnish school system is the mandate of providing equal education to all pupils. Another is the responsibility of educational officials for regulating and controlling schools. These two elements relate to how school officials can balance technology renewals with sustainable solutions in both old and new schools, which is something that can be done by drawing on each school’s own profile. This issue was also present in the strategies of the educational officials, many of whom prioritized local actors and school practices in their attempt to balance plans that were “too wild.” Furthermore,
efforts to advance the public use of the new Integrated Pilot School emphasized accountability to taxpayers, thus foregrounding the value of ensuring equality. In building the Integrated Pilot School with cutting-edge technologies, the communality model, which was derived from old village schools, was used to legitimize the city’s significant investments using taxpayers’ money. Moreover, based on the Finnish school system tradition, the position of educational officials as controllers was foregrounded, particularly with respect to company collaboration. Ultimately, although this issue was challenged in the discourse, the neutrality of company collaborations was still required, and the autonomy of the schools was emphasized. On the other hand, the traditional, legislatively regulated recruiting procedures were challenged by the use of novel recruiting and competence management processes. One alternative strategy emphasized a reliance on the schools’ human resources through the practice of providing current teachers with in-service education. Though the resultant system was based on the traditions of the Finnish school system, operational models and technological solutions derived from global networks were also promotionally introduced. In sum, the Integrated Pilot School was positioned as a pioneer and model for schools through the city—and even across the country. This process represents the strategy of challenging the traditional school model.

Interaction order: analyzing the heterogeneity, multi-voicedness, local–global tensions, and power aspects inherent in infrastructuring

With regard to participants’ interaction order, the heterogeneity and multi-voicedness of information infrastructure building and infrastructuring have already been acknowledged in the literature in terms of the ability to respond to emergent social needs (Star and Bowker 2002), the anticipation of modifiability, and the preparation for changes in information infrastructure design (Hanseth et al. 1996). These factors are related to the need for information infrastructures to adapt to local needs by recognizing the tensions that exist between local and global dimensions (Bowker & Star 1999, Star & Ruhleder 1996). Neumann and Star (1996) characterized information infrastructure building as involving designing linkages among multiple groups; making connections among many people, their world views, and their goals; and highlighting multidimensionality and multiculturalism. There have also been calls for explorations of and engagement with multi-sitedness and the local–global dimension of infrastructuring, as well as for the generation of
greater awareness of the complexity and emerging political and power-related aspects of user inclusion in infrastructuring (Karasti 2014).

The concept of interaction order encourages an examination of the relationships that exist in social interactions between actors and their possible social arrangements, which inherently include power-related aspects. The longitudinal case of the present research was carried out through various sub-projects in schools within an educational network. It involved a multitude of actors from both local and global organizations and networks. The institutional role of the school as an active actor in society called for the creation of new collaborative practices. Hence, it required a transformation of the interaction order of the relevant actors. Concerns regarding the “child’s best” clearly foregrounded the needs of children. The children acted as planners of their own school activities and were, therefore, more responsible for their own learning, thereby rearranging the interaction order. The teachers were still trusted with a considerable amount of autonomy, since they were expected to appropriate ICT within the modernized pedagogical models of the development projects. Similarly, the teachers still had considerable responsibility, even though the novel competence management and recruitment processes gave individual teachers less power in terms of choosing their own teaching methods. The collaboration models created in this study also concerned school–home communications and the active participation of parents. Furthermore, efforts to advance the possible public use of the new Integrated Pilot School foregrounded the importance of serving surrounding communities more widely, as well as accountability to taxpayers.

Through tripartite collaborations with research partners, experts from global networks, and local and global companies, new actors in the educational domain emerged. The project’s participation in global networks brought to the forefront the voices of various kind of experts. Educational officials positioned research partners primarily as supporters of infrastructuring, existing to provide scientific evidence and to develop convincing communications for educational or funding authorities. Funding authorities emerged as relatively new, yet important, actors in this domain. Inviting companies to collaborate with and provide ICT for schools also changed the interaction order. Furthermore, the schools’ active roles in defining their development efforts allowed them to have their own voices in this process, rather than serving as mere living-lab environments and testers for the ICT companies. Consequently, the positions of educational officials as controllers of company collaborations decreased in importance, while more autonomy was given to the schools. This meant that the schools had more decision power with regard to
development efforts. External resources resulted in greater decision-making power in terms of selecting and purchasing technologies for development efforts. Educational officials positioned the Integrated Pilot School as a pioneer and model for the other schools in the city and even the country. Infrastructuring efforts conducted through the various development projects and related sources of external funding positioned the schools differently, such that the schools selected as pilots were seen as “crown jewels” of the future school infrastructuring effort. Here, the need to ensure equality among schools in terms of education became significant. There was also some tension concerning the strategy of transferring ready-built models (designed by educational experts from the global networks) with cutting-edge technologies to only a few of the city’s schools. These concerns led participants to consider the creation of sustainable solutions for learning environments that would be achievable for all of the schools within the city’s educational network. The resulting strategy (i.e. creating solutions applicable to all of the city’s schools) positioned schools as active participants in the shaping of infrastructuring, rather than as executing actors of expert-driven models and solutions. The educational officials’ positions were also altered during this process: the officials positioned themselves as change agents driving the effort, and their roles changed from those of controllers to ones of ensuring equality in education.

In figure 2 below, future school infrastructuring as social action is illustrated through the nexus analytic concepts of discourses in place, historical body, and interaction order (Scollon & Scollon 2004).
Fig. 2. Infrastructuring as social action.

HISTORICAL BODY
local practices, operational models, everyday practices, technology skills, governance, tradition of equality balancing technology renewals, sustainability, company collaboration

INTERACTION ORDER
teachers, pupils, researchers, schools, educational officials, headmasters, local companies

DISCOURSES IN PLACE
promotional innovation, accountability to tax payers and society, child's best, equality in education, leadership, etiquette for tripartite collaboration, scientific evidence

Infra-structuring as social action
5 Concluding discussion

Modern IS projects tend to affect more stakeholders than traditional IS projects. The range of users in modern projects is also more variable. Thus, a need for fine-grained conceptualizations of involved actors, including users, developers, and other affected stakeholder groups, has been identified in the literature. In IS research, in particular, recent changes have increased the interest in understanding complex and large-scale efforts.

The aim of this study is to construct a better theoretical understanding of the complexity involved in infrastructuring, which was examined as the social action accomplished by various participants. This study examines the building of an information infrastructure within a novel context: an educational network of a Finnish city, which was a longitudinal case involving various sub-projects and a multitude of actors. A novel aspect of this case is the participation of children, who have not previously been studied in either the IS field or complex infrastructure development efforts. The study also contributes to the extant literature on infrastructuring by offering novel findings concerning the multitude of actors and the versatility of the objects of design involved. In this study, various central social actors were identified, including educational officials, schools (including teachers, headmasters, and pupils), researchers, and local and global companies, all of which contributed to the future school effort. Furthermore, through the context of infrastructuring, the study acknowledges the longer timescales, multisitedness, multivocalities, and political aspects involved in infrastructuring.

This study utilizes literature on user participation in ICT development, a traditional research topic in the fields of IS and HCI. Children’s participation, which has also been examined in HCI research, especially within the IDC field (e.g. Druin 1999, 2002, Druin et al. 1999, Scaife & Rogers 1999), has also been utilized. In particular, IDC research distinguishing the roles played by children in technology design processes (e.g. Druin 2002) has been considered useful. Furthermore, this study relies on contemporary ICT development literature concerning user participation (e.g. Kyng 2010, Markus & Mao 2004) to study the emergence of participatory practices for supporting the participation of a multitude of actors in the studied future school effort. Additionally, literature on various user participation models (Mumford 1983), as well as the research tradition of user participation in IS design (Bjerknes et al. 1987, Greenbaum & Kyng 1991, Schuler & Namioka 1993), has been utilized in the discussions emphasizing user participation in this effort. The theoretical framework presented in this study is
applied in order to make sense of participation in this kind of complex venture. Specifically, in this study, a socio-technical approach to information infrastructure (Star & Ruhleder 1996) is applied to conceptualize complex aspects in the effort in question, as well as to explore the participation of the various actors involved. The study also utilizes literature on participatory processes for infrastructure development (e.g. Hanseth & Lundberg 2001, Karasti & Syrjänen 2004, Neumann & Star 1996). Existing research has already demonstrated interest related to broadening our understanding of participation in complex, longitudinal infrastructure-building efforts (e.g. Karasti & Syrjänen 2004, Neumann & Star 1996). The process of constructing the future school has, in this research, been described through the concept of infrastructuring, which has been suggested in the literature as appropriate for characterizing the building and evolution of information infrastructures (Björgvinsson et al. 2010, 2012a, Karasti 2014, Karasti & Baker 2008, Pipek & Wulf 2009, Star & Bowker 2002).

Finally, this study relies on the nexus analysis approach as a theoretical and methodological framework (Scollon 2001b, Scollon & Scollon 2004) for studying infrastructuring as social action.

5.1 Summary of the results

The main empirical results of the thesis are as follows. This research examined the participation of various actors in a venture. These actors included educational officials, as well as school staff, children, companies, and researchers. Through this exploration, the research offered a nexus analytic discourse analysis of the participation of these actors in the effort to build information infrastructures for a city’s educational network, including local schools and the municipal educational administration. A number of discourses and concrete practices were found. Specifically, discourses arguing for challenging, while also appreciating and utilizing, the existing installed base were identified, as were discourses advocating equality, sustainability, continuity, and cutting-edge solutions. All of these discourses justified the wide-ranging participation of various actors. In practice, users had varying opportunities to influence the co-evolution of practices, such that teachers had more influence than pupils. Thus, this study offers a broadened conception of what ‘participation’ may entail for the IS community.

Furthermore, discourses on equality, continuity, sustainability, and cutting-edge solutions contributed to the wide-ranging reach of this effort, with the case involving a variety of actors. Children, as a relevant user group, were allowed to
participate in local ICT developments in their schools as users, informants, and testers (cf. Druin 2002). A discourse advocating children’s right to participate in matters concerning their lives was also evident in the data, though this discourse had not yet been realized in actual practice. Furthermore, the identified discourses characterized broad participation in information infrastructure-building, with an emphasis on an open opportunity to participate.

The concept of infrastructuring in an educational network included both planned and emergent activities that revealed the intimate intertwining of practice and technology. The planned activities concerned architectural evaluations, which provided the basis for the infrastructuring in the schools. Based on these architectural evaluations, the schools’ innovative learning environments were constructed. Planned activities included ICT companies’ deliveries of specific ICT solutions adapted to each Smart School setting. Emerged activities concerned the adaption of the planned architectural, interior design, and ICT solutions to each Smart School setting. Novel findings involved a multitude of actors, both adults and children, their various activities, and the versatility of the involved objects of design. The solutions produced in this educational context included: novel ICT solutions, novel architectural and interior designs, pedagogical practices, and practices and ICT solutions enabling the continuous developmental work of partners. The findings address ‘design for use before use’, which provides the starting point for infrastructuring. In this effort, specifically, ICT solution suppliers provided expertise and ICT. ‘Design-in-use’ was carried out by teachers and pupils. Furthermore, the existence of resonance activities was identified as taking place during various kinds of meetings and in-service education experiences. Finally, ‘designing for design after design’ – i.e. design for infrastructuring – was identified through the efforts of some parties in this project to create solutions to enable and support further infrastructuring.

Moreover, the nexus analytic concepts of discourses in place, interaction order, and historical body were used to better understand the complexity involved in infrastructuring. The following seven discourses were found: the ‘child’s best’ as an undeniable motivation legitimizing infrastructuring; equality in education and its role in legitimizing infrastructuring; accountability to taxpayers and society and its role in shaping infrastructuring; etiquette for tripartite collaboration intermingled with infrastructuring; scientific evidence for legitimating, if not guiding, infrastructuring; leadership discourse on financial and human resources; and promotional innovation discourse.
Through the concept of historical body, this study acknowledged the longer temporal timescales of infrastructuring, especially the past temporal horizon and the shared histories of involved communities. The concept of the installed base refers to the existing socio-technical system in which information infrastructures evolve (e.g. Hanseth & Lyytinen 2001), which inherently contains previous decisions related to technological design (Hanseth 2010). On the other hand, in the future school’s infrastructuring, the concept of historical body is viewed as offering related, but complementary insights, since it refers to the social actors’ accumulated experiences, which are inevitably present in any social action. The involved actors’ shared knowledge and accumulated experience, as social aspects of information infrastructure, shaped the future school’s infrastructuring. Focusing the analysis on the historical bodies of the actors facilitated a closer look at their in situ practices, thus foregrounding local aspects in infrastructuring. In the future school’s infrastructuring, it was common for the experiences and expertise of the local actors to be appreciated, but also challenged. The innovative ICT solutions and operational models derived from the global network and from various experts were grounded in the practices of local teachers, who were considered human resources and experts in the schools’ in situ settings. The solutions were also balanced with respect to the shared understandings within these schools, such as traditional concerns regarding equality in education. Hence, based on existing research and the empirical findings, it is clear that it is necessary to value and understand the historical aspects of infrastructuring in order to better respond to local social infrastructuring needs, as well as to counterbalance the expanded multi-sited and local-global scales (e.g. in Karasti 2014).

In addition, through the concept of interaction order, this study delved into the multi-sitedness, multivocalities, and political aspects inherent in infrastructuring. The concept of interaction order facilitated the recognition of the dynamicity of the actors’ relationships and social arrangements in relation to infrastructuring and the production and reproduction of their roles. In the empirical analysis, the central social actors and their contributions to the future school’s infrastructuring were identified. Children’s participation was emphasized in the discourse as providing motivation for efforts to modernize the traditional school and construct up-to-date learning environments and practices, although their contributions to infrastructuring remained indirect. Furthermore, the consideration of interaction order highlighted the power-related aspects connecting the educational officials with the actors within the schools. Expectations of greater flexibility on the part of the educational officials (in comparison to their traditional positions as centralized
controllers) in relation to the development efforts and collaborations with the new actors within the schools were foregrounded. On the other hand, while the schools were considered to become more dynamic societal actors, new actors were also invited to collaborate. The analysis of the interaction order, however, suggests that the schools maintained their decision power, positioning new collaborators in supporting roles. With respect to complex infrastructuring efforts, understanding the dynamic natures of social relationships was essential for identifying and responding to changing social needs, as well as potential conflicts among the various actors involved. For example, recognizing the actors’ roles also increases awareness of power-related aspects, which could be considered an arrangement for participation in infrastructuring; in this research, such recognition emphasized various actors’ participation and/or promotion of the evolving process of infrastructuring. Figure 3 illustrates the multitude of actors and their contributions to shaping the future school’s infrastructuring.

A nexus analysis was also utilized to better understand children’s participation in the infrastructuring process. It brought to the foreground the traces of children’s historical bodies as well as aspects of interaction order displaying the voices of adult as ‘others’ informing children’s contributions. The nexus analysis foregrounded the traces of the children’s historical bodies, as well as aspects of the interaction order that conceived of the voices of adults as ‘others’ informing children’s contributions. Children were involved in the infrastructuring process through the generation of ideas for a learning environment for an Integrated Pilot School. In the children’s contributions, their historical bodies, experiences, histories, and everyday practices were visible. The children suggested ideas for ICT use at school based on their everyday life experiences of technology use, with which they were already familiar. Regarding interaction order, children brought with them into the infrastructuring process the voices of their parents and teachers as influential others. The interests and everyday activities of the children’s parents also seem to be reflected in the children’s ideas. Furthermore, the children expressed a need for adult supervision and control in pupils’ ICT use. In this way, the children echoed the voices of adults. Children’s hesitance to contribute ideas of technology use that they believed to conflict with the accustomed practices of school learning was revealed through the presence of their teachers’ voices in their speech. Thus, teachers seemed to be influential adults – not only through their capacity as controllers, but also through their mediation of children’s contributions through positive attitudes concerning technology use in learning.
Next, the findings of this research will be discussed in relation to research on participation in information infrastructure building, information infrastructure,infrastructuring, and nexus analysis.

5.2 Discussion of the results

In the following, the implications of the study’s findings for research and practice are discussed.

5.2.1 Discussion of the results in relation to research on participation in information infrastructure building

To ensure the careful discourse analysis of the participation of the various actors, this research employed the three dimensions of the concept of information infrastructure (Star & Ruhleder 1996) that particularly characterize this complex venture: its reach and scope, its building and reliance on an installed base, and its links with conventions of practice (i.e. how the infrastructure both shapes and is shaped by the conventions of its community of practice).

In the analysis focusing on participation, discourses justifying the broad participation of actors were identified, as were users’ concrete participation...
practices. Interestingly, not only a discourse calling for all parties to challenge the ‘traditional school’, but also a discourse emphasizing an appreciation of local school settings and practices emerged. Both can be connected to acknowledgements of the inherited historical aspect – the inescapable effect of the installed base as a shaping feature of an information infrastructure (e.g. Hanseth 1996, 2010, Star & Ruhleder 1996). In the empirical analysis, the central social actors and their contributions to information infrastructure building for future schools were identified. In practice, both teachers and children, as future users of learning technologies and utilizers of the new pedagogical practices, participated through their schools’ local pilot projects. In this case, no explicit effort to advocate PD methods or participation was raised in relation to these two groups. User participation in the future school information infrastructure building may be characterized as participation ‘in the wild’ (Karasti & Syrjänen 2004), such that non-professional users are also allowed to participate. However, participatory activities (cf. Markus & Mao 2004) supporting user participation were identified. Though no explicit participation methods were used, participation practices for supporting user participation did emerge (e.g. enabling practices to support teachers’ participation were developed during the future school effort). Interested teachers in the Smart Schools were given the opportunity to develop and experiment with pedagogical practices, and they used ICT to create collaborative and learner-centered pedagogical practices, as well as personalized teaching. The renewal of technological equipment and these intertwined practices also had important implications for the (learning) practices of the pupils.

Furthermore, the future school effort has created an environment to support collaboration in development projects, considered also as enabling practices. To support the participation of various groups, collaborations with educational officials were established. For companies, Smart Schools offered living-lab environments for product development and experimentation in local settings. Participation activities have also been arranged to initiate tripartite cooperation with the public, research, and business sectors. The local educational administration and especially some headmasters were particularly active in creating this new kind of enabling practice, which allowed and supported school–company co-operation and development work. Co-teaching systems and pedagogical cross-grade teaching practices are also examples of these new enabling practices, which are created locally in the Smart Schools. Teacher participation was also promoted through in-service education. The importance of training in supporting user participation has been emphasized in others kinds of contexts, such as empowering workers
Thus, allocation of teachers’ resources for planning work and in-service education has been arranged in some schools during the future school effort. However, empirical data shows that involving teachers necessitates additional arrangements for their participation and may also lead to tensions with trade unions. For work allocation negotiations regarding flexibility for teachers’ development work, teachers’ unions need to be involved, since these organizations diligently protect teachers’ interests. However, in this case, none of the participation or training activities related to user participation were arranged by the trade union, as is traditional in PD research (e.g. Bjerknes et al. 1987, Schuler & Namioka 1993). Neither was there any particularly wide or systematic teacher participation in this effort, though some willing and enthusiastic teachers from certain Smart Schools did take part. Novel recruiting and competence management processes, as well as support tools, have been developed to manage the competencies required of teachers of the future school and to facilitate recruiting. However, though teachers have considerable autonomy with regard to appropriating ICT in pedagogical models, these novel competence and recruitment management processes can be considered to assign less power to individual teachers in terms of allowing them to work as they prefer.

Participation among teachers, who play an important role in shaping technologies and their related pedagogical practices, was experienced as meaningful for teaching and motivating for pupils’ learning. Furthermore, teachers began to share their experiences with the new practices and technologies within their communities. This information infrastructure building process, which was based on an appreciation of the installed base and local settings allowing user participation, thus exhibits similarities to IS theory arguing that socio-technically sound processes and user participation contribute to development and implementation success in IS development (Markus & Mao 2004: 537). Furthermore, through the creation of enabling practices to support teachers’ participation in development work, the educational officials of the future school also highlighted an appreciation for local settings and for adapting new technologies to complement local practices. The importance of such an approach in information infrastructure building was identified and related to the need to advocate for greater genuine participation of teachers and pupils in information infrastructuring building processes. This research contributes a broadened conception of what ‘participation’ may entail for the IS community.
Large-scale efforts of this kind may also benefit from more active participation by children, as it has been acknowledged that children’s participation may lead to improved decision-making (Ackerman et al. 2003). As discussed above, children, as a relevant user group, were allowed to participate in the future school project; however, their participation related mainly to shaping the ICT solutions under development as users, informants, and testers (cf. Druin 2002). Children’s participation was emphasized in the discourses as providing motivation for modernizing the traditional school, although the children’s contribution to information infrastructure building remained indirect. Children were viewed as innovative users of learning technologies, were positioned as informants in the learning environment development projects, and were allowed to experiment with novel learning technologies. Children were also invited to share their comments on and insights into various adult-created solutions, such as the architectural plans and the plans for the selection of specific ICTs in their schools’ development projects. In addition, children served as testers of a learning game and a mobile learning environment. However, since the children primarily contributed through specific development projects, their role in the overall information infrastructure building process remained quite minor. To be positioned as real design partners, the children would need to be considered equal stakeholders in the design of new technologies (cf. Druin 2002). Instead, in this study, children’s role as design partners in the complete development effort was not identifiable from the data. Hence, this study’s findings complement those of earlier research reviewing children’s participation in large-scale ICT efforts, which emphasize that the design partner role of children tends to be missing in such efforts (Halkola et al. 2012).

To concretely allow children to have a greater voice, a research intervention was arranged based on the nexus analysis research framework (Scollon & Scollon 2004), which guided the researcher to change the nexus of practice. In the arranged research intervention, children shared their ideas for a learning environment for the forthcoming Integrated Pilot School. The intervention followed the principles derived from IDC literature (Druin et al. 2001, Scaife et al. 1997). In addition to participating in interviews, the children took part in arranged workshops, which fostered active participation through such methods as playing games, playing, developing ideas, and planning collaboratively. Some children were even able to invent new pedagogical practices, indicating ways they would like to be taught (e.g. through play or by personalizing teaching to match learners’ interests). In the pedagogical domain, these kinds of child-ideated pedagogical practices could be utilized in learning. However, with regard to ICTs, the children suggested only
mundane ICT solutions that were already widely used in schools (e.g. PCs, mobile phones, the Internet, and different kinds of games). Their suggestions in this field can be seen as imitating or echoing adults’ voices. On the other hand, imitation has been reported in the literature as very natural for children and one way in which human beings learn (Kuure et al. 2010). Again, the ICT solutions adapted in the Integrated Pilot School and Smart School practices included similar kind of technologies – PCs, learning games, and mobile technologies. Although the future school efforts were promotionally emphasized as relying on the most cutting-edge ICT solutions, the adults produced technologies similar to those suggested by school children – that is, technologies that reflected their everyday technology usage. Hence, the results of the research reveal that the schools within the future school effort, though they serve as pioneers within the city’s educational network, are actually not particularly advanced in terms of adapting new ICT solutions. These findings are supported by previous literature suggesting that schools lag behind recent developments in ICT (Kinnula et al. 2015).

Within the research intervention approach described above, the children indeed showed their competence in finding new pedagogical practices to support their learning. The nexus analytic approach for analyzing the historical body aspect (Scollon & Scollon 2004) of the actors involved in order to understand their accumulated experiences can be used to inform the arrangements of the participatory activities involving children. Moreover, interaction order issues (Scollon & Scollon 2004), which are inevitably intertwined with aspects of the historical body concept, are useful for understanding the dynamicity of the social relationships among the various actors – both adults and children – involved. An understanding of the actors’ relationships could also be applied for finding new approaches to foster conditions for children’s participation.

Traces of the children’s historical bodies, as well as aspects of the interaction order foregrounding the voices of adults as ‘others’ informing children’s contributions, were identified from the data. The nexus analysis brought to the foreground the children’s tendency to suggest ideas for ICT use at school based on their everyday life experiences, thus reflecting their historical bodies. For learning purposes, children suggested the use of technologies with which they were already familiar. The children also brought with them into the information infrastructuring process the voices of their parents and teachers as influential others. Finally, the interests and everyday activities of the parents seem to be reflected in the children’s ideas. Interaction order issues in the children’s contributions also revealed the power aspects among adults and children: for example, the children expressed a
need to be supervised and controlled in their ICT use by adults. In this request for supervision, the children were echoing the voices of adults. Furthermore, the voices of the children’s teachers manifested through their hesitance to contribute ideas of technology use that they believed to conflict with the accustomed practices of school learning. Thus, teachers seemed to be influential adults with authority over school children. However, teachers did not only display as controllers; they also mediated children’s contributions through their positive attitudes towards technology use in learning. The power relations between adults and children, as well as various methods for resisting such relations, have been well acknowledged in IDC literature (e.g. Druin 1999, 2002, Druin & Solomon 1996, Druin et al. 1997, 1999, Guha et al. 2013, Hanna et al. 1997, Pardo et al. 2005, 2006, 2008). The nexus analytic concepts of historical body and interaction order (Scollon & Scollon 2004) could be utilized to inform such participatory efforts and to equalize the various power-related tensions that exist between adults and children.

With regard to selecting child participants, in this effort, the adults (e.g. educational officials, usually headmasters, teachers, and experts with formal positions) selected the participant representatives from among the pupils – and, thus, could be considered to act as change agents. In contrast to what is normatively argued in IS literature, it has been shown in previous research that actor groups other than IS professionals may act as change agents, thus creating opportunities for users to participate in IS development projects (Markus & Mao 2004). In the future school effort, the elected representatives of the student bodies were also selected as participants in the ICT development projects. The selection of the children’s representatives in this effort was, hence, based upon the practices of the local schools as the installed base of infrastructure (e.g. Star & Ruhleder 1996). This kind of participation model is in line with the IS tradition recommending that elected user representatives in IS projects be equal participants in decision-making (e.g. Mumford 1983). However, new participatory practices would be needed to support such participation. In this effort, the value of training in supporting participation has already been shown among adults. Furthermore, training related to participatory practices in the ICT development context has already been shown to provide new tools and skills for children, thus increasing their ability to act as design partners (cf. Guha et al. 2013). Most importantly, the training of school children would increase their understanding of their right to participate.

In this effort, school activities to foster children’s participation through training activities on inclusion with meeting practices or through participation in citizen meetings have already been arranged; these activities begin when the children are
in the third grade. Moreover, in addition to general student bodies within the schools, city councils were also seen as ways for children to take part in decision-making concerning the matters that affect their lives. Such emphasis on children’s right to participate was discursively advocated, despite the lack of concrete plans for participatory activities in the emerging future visions. In the future, children were also envisioned to be involved in the learner-centered development of specific ICT, even from the early stages of the development process. Hence, a broader approach to school children’s rights to affect and participate in matters concerning their lives was supported by various adults in the future school effort. In the literature, approaches related to children’s participation have also been discussed on the basis of recognizing children’s rights to affect matters concerning their lives. Children’s fundamental right to citizenship emphasizes and advocates the participation of children in meaningful projects with adults as a form of democratic participation (Hart 1992). These traces of children’s more genuine participation were identifiable from the data, but have been hardly addressed in IS literature, except in Iivari et al.’s (2015) research relating children’s genuine participation to ICT design.

In other complex ventures, such as urban and environmental planning efforts, children have also participated within intergenerational groups in the co-design of various environments (e.g. Saad-Sulonen & Horelli 2008), such as yard environments (e.g. Saad-Sulonen & Cabrera 2008, Saad-Sulonen & Horelli 2010). A resemblance can be seen between the identified traces of children’s more genuine participation in future school efforts and complex attempts in the field of CI focusing on children’s empowerment in participatory urban planning and design and on ICT-mediated participation (e.g. Saad-Sulonen & Cabrera 2008, Saad-Sulonen & Horelli 2010). As already mentioned, in the future school effort, school activities for fostering children’s participation in society had already been acknowledged. On the other hand, in the urban planning efforts, children appropriated ICTs during the design process, which was viewed as empowering adolescents to become digital citizens –both as expert ICT users and as active persons – instead of only as utilizers or consumers of technologies (Saad-Sulonen & Horelli 2010). Moreover, the social recognition that children have rights, including the right to have a voice in decisions that affect their lives, has been related to the environments in which children live as important arenas for shared decision-making. From this perspective, children’s meaningful participation is suggested to grow out of the features of everyday community life that afford children’s meaningful participation. (Chawla & Heft 2002.) Some resemblance in
terms of efforts allowing children to influence their environments can also be found between environmental planning attempts and the design of learning environments within the future school effort. In a previously studied urban planning effort, a group of children co-designed a yard within an intergenerational design team. Within the future school infrastructuring project, children participated in interior design through infrastructuring activities, commenting on plans for learning environments in their schools. In both of these efforts, the children appropriated ICTs into their practices: within the future school infrastructuring, ICTs existed in their learning practices, and in the urban planning effort, ICTs existed in the co-design practices supporting their participation (Saad-Sulonen & Horelli 2010).

School children’s rights to affect their lives and to participate in decision-making concerning their environments corresponds with their participation in activities affecting their learning environments, such as infrastructuring activities. This approach also corresponds with the power-related aspects addressed in infrastructuring efforts within the PD approach, which call for researchers and designers to be more aware of the possibility of creating absences, exclusions, and deletions through currently used infrastructuring methods (Karasti 2014). To change the nexus of practice within this research, a research intervention was arranged to particularly target children’s participation in future school infrastructuring. However, within the future school effort, children themselves were not allowed to set goals for the development efforts in which they were allowed to participate, despite this approach being recommended in research methods supporting inclusive participation. In the literature, the importance of allowing children to design the goals of projects in which they participate has been considered to foster the children’s sense of ownership – and, hence, their motivation and competence (Hart 1992).

Ethical aspects of children’s participation have been considered in relation to the future school effort, but also in the wider context of engaging and strengthening children’s participation. In this research study, the activities engaging the school children and their elected representatives were conducted under the supervision of educational officials in various positions. The educational officials, as representatives of the schools, were also responsible for the procedures of the children's participation, since they were aware of the children’s ages and developmental stages during the children’s participation. Permission for the children’s participation, including written consent for the research interventions, was obtained from the children’s parents.
The differences between the contexts of information infrastructure building in traditional IS projects and in this information infrastructure building effort also have implications for user participation (Markus & Mao 2004). The extension of user participation in today’s varied IS context poses challenges related to involving users in a variety of participation activities, including all aspects of solution development (cf. Markus & Mao 2004). In the future school effort, the participatory activities covered both pedagogical practices and technologies. The pedagogical practices were developed in conjunction with the implementation of various technologies, which were clearly entwined in use situations and which allowed users to participate. Specifically, various actors and user groups were allowed to participate, together with ICT, in developments including architectural, interior design, and enabling solutions. The findings of this research complement those of earlier research on participation in traditional IS projects, which typically emerge through requirements analysis and the testing or prototype evaluations. By contrast, today’s varied IS contexts, such as the building of infrastructure, often involve users in a variety of participation activities, including both technical and non-technical activities (cf. Markus & Mao 2004: 522). With regard to user participation this effort differs from traditional IS development processes, which usually are pre-defined and based on specified user needs determined by professional designers at the beginning of the development process (e.g. Hanseh 2010).

5.2.2 Discussion of the results in relation to research on information infrastructures and infrastructuring

In the previous section, information infrastructure building has been discussed from the perspective of the participation of various actors. This section continues the discussion of the results in relation to research on information infrastructures and infrastructuring; however, it focuses on other aspects. In the analysis focusing on participation, discourses justifying the broad participation of actors were identified, as were users’ concrete participation practices. Interestingly, not only a discourse calling for all parties to challenge the ‘traditional school,’ but also a discourse emphasizing an appreciation of the schools’ local settings and practices emerged. It was revealed in this effort that the installed base emerged in a sense of inertia, which posed challenges related to developments, but also in a sense of appreciating the existing installed base. This is in line with the notion of information infrastructures (Hanseth 2010, Star & Ruhleder 1996). Both for challenging the ‘traditional school’ – i.e. the installed base – and for appreciating it, the wide-
ranging participation of different kinds of actors was needed. Ultimately, various actors contributed to the infrastructuring effort. Furthermore, the concept of infrastructuring (Star & Bowker 2002) was utilized to characterize the building and evolution of the information infrastructure (Björgvinsson et al. 2010, 2012a, Karasti 2014, Karasti & Baker 2008, Pipek & Wulf 2009).

In this study, the evolving infrastructure was considered to be a complex, socio-technical system (Hanseth 2010, Star & Ruhleder 1996), into which ICT solutions were offered by ICT companies that were ‘designing for use before use’ (cf. Ehn 2008). Meanwhile, the analytic focus was on the other kinds of solutions that emerged as the result of, or along with, the adoption of these ICT solutions. From the viewpoint of IS research, therefore, this study addresses how infrastructuring, at least in this educational context, concerns pedagogical, architectural, interior design, and enabling issues – thus revealing that, in the creation of novel learning environments, all of these aspects may play a role together with ICT. Thus, both technology and work-related developments (Pipek & Wulf 2009) – i.e. technical, social, and spatial developments (Ehn 2008) – are acknowledged, as is the design of the ‘surroundings’ (Pipek & Wulf 2009). The existing literature allowed to broadly examine infrastructuring as a reconceptualization of one’s own work in the context of existing, potential, or envisioned ICT tools – a natural part of every user’s activities (Pipek & Wulf 2009). However, this research also acknowledged ‘design for use before use’, which provides the starting point for ‘design-in-use’ – i.e. ‘infrastructuring’ (cf. Ehn 2008). Teachers, as the influential creators of novel pedagogic practices, were involved in ‘design for use before use.’ They also appropriated certain pedagogical practices that were intertwined with the use of modern ICT as ‘design-in-use.’ Pupils also appropriated such practices, e.g. learning at school, creatively in their work; this practice can also be acknowledged as ‘design-in-use.’ Additionally, this research acknowledged the resonance activities that involved observing and communicating aspects of infrastructure (Pipek & Wulf 2009). These were interpreted, in the arranged meetings, as commentary by teachers and pupils on the solutions created. Additionally, teachers shared their wider experiences in the educational network and gained in-service educational opportunities. Finally, interesting observations relating to ‘designing for design after design’ (cf. Ehn 2008) emerged, in the sense that some parties created solutions to enable and support such infrastructuring activities. These activities included the headmasters and educational officials making arrangements for teachers’ development work; the educational officials arranging company–school cooperation efforts; and the companies, headmasters,
and educational officials developing ICT and practices for recruiting the ‘right’ kinds of teachers for the future school.

Moreover, to construct a better theoretical understanding of the complexity involved in infrastructuring involving various participants, the project was examined from the nexus analytic perspective as social action (Scollon & Scollon 2004). This detailed analysis was especially sensitized to the three facets of social action that shape the process of infrastructuring: discourses in place (i.e. those emerging here and now), interaction orders among the various stakeholders, and the historical bodies of the participants. This study made visible the existence and value of these nexus analytic concepts. The framework also guided the study in recognizing the dynamicity inherent in the concepts of historical body and interaction order. Even when intertwined, both concepts provided distinct perspectives into the social action under scrutiny.

Within this study, the analysis was directed towards the micro-actions of the actual infrastructuring effort, while the nexus analysis instructed the recognition of connectedness in small-scale development efforts and in the infrastructuring effort as a whole. The nexus-analytic concepts allowed a closer look at the sociocultural histories and social arrangements behind the social action (Scollon & Scollon 2004) through the “infrastructural inversion” (Bowker 1994) that foregrounded the transparent, background, and historical elements of infrastructure (Star & Ruhleder 1996).

This study maintains that the concepts of interaction order and historical body are both useful for analyzing the development and evolution of complex and heterogeneous large-scale technological systems and infrastructuring involving a multitude of actors. Therefore, the contribution of this research is to offer IS researchers tools to make better sense of the complexities involved in infrastructuring. As emphasized in the existing literature, infrastructuring is separate from professionalized design. It is, instead, seen to include various kinds of people as potential ‘users’ and ‘designers,’ who are also greater in number and more diversified (Björgvinsson et al. 2010, 2012, Karasti 2014, Karasti & Baker 2004; Karasti & Syrjänen 2004, 2008, Pipek & Wulf 2009). By acknowledging this, the concept of interaction order provides valuable insight into power-related aspects, e.g. when arranging possibilities for various actors to participate and contribute to infrastructuring. The concept of interaction order as an analytical tool is also valuable for mediating and designing linkages among multiple actor groups (Neumann & Star 1996). This study also acknowledges the openness of infrastructuring, or “leaving partly open the participants and the way they may
appropriate information infrastructure” (Ehn 2008). Furthermore, the use of historical body as a tool sensitized the analysis to the local practices and shared history of the community, which was accumulated in the actors’ experiences and in elements of the installed socio-technical base (Hanseth 2010), which was the existing information infrastructure base to which the new elements had to adapt (Star & Ruhleder 1996). These historical and power-related understandings may also be considered to promote further development or as points for infrastructuring (Pipek & Wulf 2009), which are also valuable for informing the participation of social actors. Moreover, recognizing historical aspects may facilitate useful responses to emerging local social needs in infrastructuring and may also inform the balancing of changes in relation to infrastructuring’s expanded multi-sited and local-global scales (e.g. in Karasti 2014).

5.2.3 Discussion of the results in relation to the nexus analysis

The framework of the nexus analysis (Scollon & Scollon 2004) provided methodological tools for exploring participation as social action (Scollon 2001b), making it possible to consider participation both from the point of view of concrete practices and from the perspective of wider discourses. A more detailed study of infrastructuring as social action was elaborated in relation to the three facets of social action: historical body, interaction orders, and discourses in place (Scollon & Scollon 2004). Through the nexus analysis, all of these aspects were illustrated with regard to how they shaped the process of infrastructuring the future school. Thus, this study has made visible the existence and value of these nexus analytic concepts. The framework also guided the recognition of the dynamicity inherent in the concepts of the historical body and interaction order – which, although intertwined, provided distinct perspectives into the social action under scrutiny. The nexus analysis was directed towards the micro-level of the infrastructuring effort, but was also instructed to recognize the interconnectedness between the small-scale development efforts and the entire infrastructuring effort. In analyzing the infrastructures, the nexus analytic concepts allowed a closer look at the sociocultural histories and social arrangements behind the social action under study (Scollon & Scollon 2004) by facilitating an ‘infrastructural inversion’ (Bowker 1994) to foreground the transparent, background, and historical elements of the infrastructure (Star & Ruhleder 1996).

The analysis proceeded through the nexus analytic phases of engaging, navigating, and changing. The research process was initiated through a broad
discourses survey (Scollon & Scollon 2004), which sought to map the prominent discourses of the topic and the most important participants. As a researcher, I entered the community being researched (i.e. engaged with the nexus of practice) through my identification of the participants selected as the interviewees in this study. I also acted as a researcher in the position of an interviewer by interviewing the key actors of the nexus of practice under study. As a researcher, I also established a zone of identification with the nexus of practice, which was the infrastructuring of the future school effort. Furthermore, in the interview situations, I was positioned as a recognized actor as a researcher within the studied nexus of practice. I also explored the social action of infrastructuring within the future school effort and examined the participation of its various actors through a collaborative data analysis involving the identification of discourses. Furthermore, I co-authored research papers collaboratively with five other researchers – and, later, also authored paper more independently. Moreover, I participated in the research intervention seeking to change the nexus of practice by allowing children to have a greater voice in the Integrated Pilot School effort. While positioned as a supervisor of the student project and arranging workshops with children, I gave the students written instructions based on existing research before the sessions, which guided, for example, the behavior of the student group members with children. I followed the arrangements for the workshops within the school environment and participated in the workshops primarily as an observer; however, I also acted as an advisor when needed, following the children’s participation conditions. All of the participants of the workshops were presented for the children at the beginning of each workshop. If the children appeared to have problems collaborating or needed adult guidance, I participated as a supervisor, although the primary responsibility for the workshops remained with the student group members. The results of this research intervention were exploited through dissemination to the headmaster of the Integrated Pilot School and within the educational network. I also visited the Integrated Pilot School as a research group member, under the guidance of the school’s headmaster.

The emphasis and starting point for this research was related to participation in the school context, which explored school children’s participation as one group of stakeholders. With my historical body as the parent of a primary-school-aged child, I considered the school environment and children’s positions within, as well as related topics of technology use, to be part of my family’s everyday life considerations. Moreover, from this perspective, it was easy to advocate for children’s participation and for their ability to affect the learning aspects of their everyday environments. Furthermore, I have personal interest in the domain of
education from my position as an educator in university IS courses and through the
teacher training in which I have been participating. These accumulated experiences,
which comprise my historical body, have also motivated my approach to this
research topic. Naturally, my experiences with the ICT field as both a researcher
and a practitioner set the premise for my interest in being an IS researcher. On the
other hand, I realized certain alterations to my perspective as a result of this
research. First, the focus of the research evolved from first targeting complex ICT
development efforts through the related literature on HCI and IDC, to later focusing
on the even more complex development efforts of information infrastructures and
infrastructuring. These conceptualizations led me to also review the literature on
complex efforts involving children in urban planning, since, in this field, children
have been involved in projects in which they have been allowed to participate in
planning their environments as members of intergenerational teams. This literature
led me to research fields in which I am experienced as, for example, a biologist
participating in land use and environmental planning projects – another part of my
historical body. As I reflected on the research findings of this study as they relate
to the urban planning literature, my familiarity with urban planning issues gave me
another viewpoint from which to emphasize children’s participation as part of the
intergenerational group of stakeholders and as planners of their own life
environments. This point of view also gave me the distance needed to explore the
IDC approach to children’s participation within settings fully defined by adults, and
it further directed me towards a broader approach to advocating children’s
participation as stakeholders affecting their own life environments, as well as
research attempts to allow children to set their own goals for participation.

In this research on participation in infrastructuring the future school, a new
approach of the nexus analysis was applied within the IS research field. Through
this multidisciplinary collaboration, the nexus analysis framework applied in this
research was also introduced to the Information Processing Science Department of
the University of Oulu, where this study was conducted. This research also opened
up a new nexus analytic research direction in the IS research field, which has since
been applied in several research projects and which has begun to be utilized in other
dissertation works within IS research.

In addition to the social action under study – infrastructuring within the future
school effort – I also came to reflect on another kind of practice: that of conducting
a multidisciplinary dissertation work by collaboratively writing research papers
with a group of other researchers. Working with a topic focused on participation
and empowering, while simultaneously seeking to change prevailing practices,
sensitized me to reflect on my own position as a participant within research collaboration projects. Collaboration with experienced researchers allowed me to practice my scientific writing skills and provided me valuable feedback during the dissertation process. Other, more experienced researchers, each with their own research interests, collaborated with these same data, thus mediating the formation of this research. This collaboration also partly influenced my creation of a relationship with the research topic. Hence, writing my licentiate thesis in the middle of this dissertation process gave me more practice in scientific writing, ultimately bringing me a sense of empowerment with this research topic. On the other hand, during the learning process of writing my dissertation work, I was also able to grow as a researcher, ultimately taking more responsibility for analyzing and writing the papers included in this dissertation thesis under the guidance of my supervisors within the multidisciplinary setting.

Overall, I have acted in a variety of positions, including those of supporter, supervisor, and researcher, during the different research situations and the engaging, navigating, and changing phases of the nexus analysis of this research process (e.g. conducting interviews, analyzing data collaboratively and individually, and co-authoring and individually writing this dissertation thesis). Reflecting on my own position in relation to the research process also fostered my understanding of the interaction order aspects that are inevitably inherent in all social relationships and arrangements. The process of gradually becoming, through these many positions and research phases, part of the social action under study also allowed me to understand the complexity involved in such actions, which also allowed me to realize the various discourses involved and their background meanings. Furthermore, developing such an intimate understanding of the subject of the research, which was accomplished by taking on such a variety of positions, also guided me in exploring the related research literature. Furthermore, the versatility of the acquired perspectives also promoted a more diversified interpretive analysis.

5.3 Answers to the research questions and contributions of the research

The findings and contributions of this research are presented below, and the answers for the following three research questions are also summarized:
Research question 1 (RQ1): How can one characterize the participation of the various actors in the complex process of building an information infrastructure for an educational network?

Research question 2 (RQ2): What are the characteristics of children’s participation in this effort?

Research question 3 (RQ3): What are the characteristics of infrastructuring in the school context?

5.3.1 Summary of the findings and contributions – answering research question 1

This study offers a fine-grained nexus analytic discourse analysis of the participation of various actors in an effort to build an information infrastructure for a city’s educational network. This study has made visible the variety of actors participating in the effort of information infrastructure building for the future school.

The identified discourses have argued for the participation of a variety of actors, including users and different kinds of stakeholder groups. The various stakeholder groups that were involved in the effort as participants included educational officials of the city, different kinds of local and global companies, researchers, and the Smart Schools themselves (including their headmasters, teachers, and school children). In particular, teachers – and, in some cases, also the schools’ headmasters and pupils – were allowed to participate in their schools’ development projects as users of the technologies and utilizers of the new pedagogical practices.

A number of discourses and concrete participatory practices were identified. The fine-grained analysis revealed future paths for user participation, suggesting that more genuine participation of teachers and pupils as parts of the infrastructuring process should be advocated.

This study expanded the existing understanding of participation ‘in the wild,’ involving no concrete participatory design activities.

It was determined that the participation of actors could be supported e.g. through enabling practices, as shown in this study in relation to teachers and pupils.
5.3.2 Summary of the findings and contributions – answering research question 2

- The study examines infrastructuring in-depth and in a novel context, including examining children as an unusual group of participants that has thus far been almost entirely neglected in IS research.

- Children were allowed to participate in their schools’ local ICT development as users, informants, and testers (Druin 2002). Traces of more genuine children’s participation were also identified. More genuine participation is suggested to broaden the concept of children’s participation.

- School children were involved in technical (ICT-related), social (pedagogical) and spatial (architecture- and interior design-related) design activities of infrastructuring. The children appropriated ICT into their learning practices, a process that is considered to represent design-in-use. Children also participated in resonance activities in the form of student body meetings.

- Children’s more genuine participation, as well as their right to affect and participate in matters concerning their lives, was discursively advocated. It seemed that, in this effort, adults were acting as change agents, using their formal positions to select participant representatives from among the population of pupils. Children were allowed to have more of a voice through a research intervention that sought to change the nexus of practice. Children were involved in the infrastructuring processes through their generation of ideas for a learning environment for a multipurpose community center – a process during which their expectations and development ideas were gathered.

- Children were capable of ideating ICT solutions to support their learning, as well as of linking these solutions with some of their learning practices. Children even invented some new pedagogical practices. The nexus analysis brought to the foreground traces of the children’s historical bodies, as well as aspects of interaction order displaying the voices of adults as ‘others’ informing the children’s contributions. No nexus analysis of children’s participation like the one presented here has previously been conducted.

- The historical bodies of the participating children were displayed in this research, and their experiences, histories, and everyday practices were visible in the data. Children’s ideas for ICT use in their schools were based on their everyday life experiences of technology use. That is, the children tended to suggest ICT uses with which they were familiar.
The children brought with them into the infrastructuring process the voices of adults, including their parents and teachers, as influential others. These voices were present throughout the children’s participation and informed their contributions. These adults’ interests and everyday activities were reflected in the children’s ideas. Furthermore, the children were seen to echo the voices of adults, e.g. when they requested supervision and control for their ICT use. In particular, teachers seemed to be influential adults, acting not only as controllers, but also mediators of children’s contributions, simply through their positive attitudes concerning technology use in learning. The children’s hesitance to contribute ideas for technology use in school revealed the voice of authority of their teachers.

5.3.3 Summary of the findings and contributions – answering research question 3

This study offers new findings concerning the multitude of actors and the versatility of objects of design involved in an infrastructuring effort. The infrastructuring effort under study included both planned and emergent activities and revealed the intimate intertwining of practices and technologies. The planned activities concerned architectural evaluations, which provided a basis for the infrastructuring in the schools and for their innovative learning environments. The planned activities also included the ICT companies’ delivery of specific ICT solutions adapted to each Smart School setting (i.e. the companies designed for use before use). The planned architectural, interior design, and ICT solutions all required adaption to local Smart School settings, requiring emergent activities in infrastructuring. In the future school’s infrastructuring, the emerged activities related to the educational officials’ enabling practices; the teachers’ experimentations with and appropriations of ICT, which were intertwined with their pedagogical practices; and the making of local (i.e. school-level) decisions regarding technology use.

A nexus analytic approach for studying infrastructuring as a social action was applied (Scollon & Scollon 2004). The nexus analytic concepts of discourses in place, interaction orders, and historical body were used as methodological tools for analysis in order to better understand the complexity involved in infrastructuring. A set of discourses, as well as aspects of interaction orders and historical bodies, were identified from the research material.
The seven discourses that circulated around the future school effort were as follows: the ‘child’s best’ as an undeniable motivation for legitimizing infrastructuring; equality and its role in legitimizing infrastructuring; accountability to taxpayers and society and its role in shaping infrastructuring; etiquette for tripartite collaboration intermingled with infrastructuring; scientific evidence for legitimating, if not guiding, infrastructuring; leadership discourse contemplating financial and human resources; and promotional innovation discourse.

Through the nexus analytic concept of historical body, this study acknowledged the longer temporal timescales inherent in infrastructuring. In particular, the past temporal horizon and the shared histories of the involved communities were displayed. The analysis of the historical bodies of the actors closely examined their *in situ* practices, thereby foregrounding the local aspects in infrastructuring. In the future school’s infrastructuring, the experiences and expertise of the local actors were both appreciated and challenged. Local teachers were considered to be human resources and experts of their schools’ local, *in situ* practices. The teachers also grounded the innovative ICT solutions and operational models derived from the global network into local practices. This study emphasized the importance of valuing and understanding the historical aspects of infrastructuring in order to respond to the local social needs of infrastructuring, while also counterbalancing multi-sited and global-local scales. Through the concept of interaction order, the study explored the multi-sitedness, multivocality, and political aspects of infrastructuring. The research also revealed the multitude of actors and their contributions to shaping the future school’s infrastructuring. The concept of interaction order offered tools for making better sense of the complexity involved in infrastructuring. It also provided valuable insight into the power-related aspects useful in, e.g., arranging the participation of various actors and supporting their ability to contribute to infrastructuring. The concept of interaction order as an analytical tool was valuable for studying the participation of multiple actor groups and their power relationships.

This study contributes to socio-technical infrastructuring approaches by emphasizing the power-related aspects that shape infrastructuring. The nexus-analytic concepts utilized in this research should also be more generally useful to IS researchers for acknowledging the evolutionary development and complexity of current ISs. Finally, the provided theoretical tools respond to
increased interest within IS research in complex IS solutions that link diverse systems and numerous actors both organizationally and geographically.

This study also contributes to the IS field by addressing the school context and the user group of children, who have not previously been studied in the IS field or in infrastructuring efforts.

5.4 Practical implications

The effort of building information infrastructure for the educational network of future school was a longitudinal process involving various actors. In this effort, the technological developments were intertwined with the local schools’ everyday practices. The building of information infrastructures through the local and situated subprojects brought variety to the installed infrastructure base and served as a foundation for the ICT developments, thus also creating possibilities for new practices of participation. Situated development efforts for appreciating local settings (in this effort, the local school practices) can inform and help to mediate the specific needs of affected stakeholders and user participants. With regard to user participation, this study argues for the development of supporting and enabling practices for the participation of a multitude of actors, as occurred in this case.

Moreover, with regard to implications for practice, this research suggests that practitioners should consider, whether the spatial aspect of their case – i.e. the design of the surroundings – and not only the technology and work-related developments, is relevant. Another novel angle for practitioners to consider is ‘designing for design after design’ – i.e. design for infrastructuring. It is known that ‘design for use before use’ and ‘design-in-use’ take place; however, in this case, some parties create solutions to enable and support further infrastructuring. These could be beneficial in other settings. This study also highlights the importance of resonance activities, which, in this effort, took place during various kinds of meetings and in-service education.

This study maintains that the nexus analytic concepts of discourses in place, interaction order, and historical body are useful for analyzing the development and evolution of heterogeneous and complex large-scale technological systems and infrastructuring efforts involving a multitude of actors. Therefore, the contribution of this research is to offer IS practitioners tools to make better sense of the complexities involved in infrastructuring.

For IS practitioners, this study suggests that the nexus analytic concepts of historical body and interaction order may be useful for gaining a better
understanding of local settings and the power relationships of various actors. Such knowledge should help to mediate the specific needs of the affected actors and user participants. A recognition of the actors’ roles increases awareness of power-related aspects – and, thus, should be taken into consideration in arrangements for the participation of various kinds of actors in infrastructuring. Moreover, being aware of the power-related aspects influencing relationships between adults and children is useful in arranging possibilities for children’s participation.

Overall, this research suggests that IS practitioners apply the nexus analytic concepts of historical body and interaction order in cases of IS adoption and implementation involving multiple actors, as well as in analyzing results. Moreover, the findings of this study, which was conducted in a school context may be applicable for infrastructuring efforts in other administrative fields that place similar historical emphases on the equal availability of services.

5.5 Evaluating the interpretive research

Rather than using the validity criteria commonly used in IS research, this research applies the evaluative criteria for interpretive field research (Klein & Myers 1999). Specifically, the research has implemented a set of seven principles for interpretive field research (Klein & Myers 1999). These principles of interpretive field study are as follows: the fundamental principle of the hermeneutic circle, the principle of contextualization, the principle of interaction between researchers and subjects, the principle of abstraction and generalization, the principle of dialogical reasoning, the principle of multiple interpretations, and the principle of suspicion (Klein & Myers 1999). The nexus analytic framework (Scollon & Scollon 2004) used in this study guided the research from the beginning, encouraging a reflection on both the research process and the researcher’s own position in relation to the research topic under study. This reflection, which occurred over the course of the years during which the research process took place, was essentially interlinked with the nexus analytic research approach (also presented in the section 5.2.2.) and resonates with the fundamental principles for interpretive research evaluation (Klein & Myers 1999) presented in the literature, especially the fundamental principle of the hermeneutic circle. Furthermore, the nexus analytic concepts of discourses in place, interaction order, and historical body led the analysis to contextualize and critically reflect on the social and historical backgrounds of the research setting, which responded to the interpretive research evaluation principle of contextualization (Klein & Myers 1999). Moreover, with its focus on social action, methods for
conducting interviews, and discourse analysis, the nexus analytic perspective directed the researcher to reflect on the social construction of the research materials and to recognize the interaction between the researcher and the research participants. Hence, this qualitative research approach clearly required critical reflection on how the research materials were socially constructed, taking into account the principle of interaction between researcher and subject (Klein & Myers 1999). Based on this reflection on the social construction of the research materials (Klein & Myers 1999), it was decided that this nexus analytic research should target the changing nexus of practice, which shifted to involve children through interviews and the arrangement of a research intervention for their participation. To conceptualize the future school effort and the participation of the actors involved, the examples foregrounded in the interviews with the social actors were also explored in relation to the theoretical concepts of socio-technical information infrastructures and infrastructuring. These theoretical explorations answered the requirements defined in relation to the principles of abstraction and generalization and of dialogical reasoning (Klein & Myers 1999). Moreover, the principle of multiple interpretations (Klein & Myers 1999) was taken into account through the participation of teachers in this research – and, specifically, through the presentation and analysis of their viewpoints of the future school effort. However, the principle of suspicion (Klein & Myers 1999) was not exclusively qualified, since this would have required a different kind of critical research setting from the very beginning of the research project. Nevertheless, the pervasive promotional discourse identified in this research (see article VI) indicates an alternative way of considering the principle of suspicion (Klein & Myers 1999). Overall, this research has taken into consideration the set of the above-presented principles for interpretive field research (Klein & Myers 1999), with the principle of suspicion being considered only peripherally.

5.6 Limitations and paths for future work

With regard to the limitations of the study, the data were collected from only a single case. However, when analyzed from a discourse perspective, these data provided a rich and abundant resource for further study. In fact, the present study could be further elaborated to gain an even better picture of the dynamics and intricate arrangements of the involved relationships and to achieve a deeper understanding of the roles of the various actors and their interactions in this large-scale, long-term infrastructuring effort.
Although the data and documentation related to infrastructuring and the future school concept were gathered through a research intervention conducted with children, the discourse analysis for this research focused on adult interviews; this discrepancy represents a limitation of the study. However, these informants were considered key actors in the effort and, thus, offered valuable insights. Moreover, the nexus analysis provided a lens for examining the data and exploring the focal phenomenon in a detailed manner from a variety of perspectives.

With regard to future research paths, it would be interesting to gather data from a different infrastructuring effort. Such data could be analyzed using the same concepts in order to provide a comparison with and reveal further insights into our results. It would also be beneficial for further studies to address the differences between the ANT-originated concept of the installed base and the nexus-analytic concept of the historical body, particularly with respect to the historical aspects of infrastructuring.

The analysis of this research illustrates the extreme complexity involved in this kind of development effort. This case involved various actors, all acting from different positions in the educational network, with established practices that might be difficult to change. However, it became clear in the analysis that the challenges that emerged in this process and that were described as challenging the traditional school were dispelled. Instead, in their discourses, the actors legitimated their positions in the process through promotional talk that involved dispelling the challenges. These findings, however, were not elaborated further in this study, since they arose at more of a linguistic level. A future study of these challenges would be of interest; moreover, the wider research project context to which this study belongs may provide additional evidence supporting these findings. Furthermore, future research should continue to conduct literature reviews on children’s participation and how it is addressed in the contemporary IDC literature.

Some school children were interviewed in relation to the arranged research intervention. However, interviewing the school children more widely was considered to fall outside of the scope of this study. The numerous school children involved in the conducted projects were dispersed to different schools within the city, and some of them were involved years ago. It would be interesting to continue this research by interviewing both children and teachers, as well by gathering other types of data (e.g. observed practices in situ). However, some of the school children were involved in future school infrastructuring through the research intervention, which included interviews and workshops with the children for the purpose of identifying their expectations of the Integrated Pilot School under construction. In
addition, the interviews and workshops were arranged at the schools of the participating children. It has been argued in IDC research (e.g. Druin et al. 2001) that arranging research attempts within a school environment may influence children’s contributions. Moreover, the traditional power relations (Druin 2002) between teachers and pupils – including, in this research, teachers’ presence – may affect children’s suggestions. Therefore, it is recommended that research interventions of this kind be arranged in environments other than children’s school environments. In addition, during the research interventions involving the school children, the children’s teacher was also present, even though not actively participating in the research activities. Future research should take into consideration that, when children’s teachers are present in research interventions, it could be planned and arranged for the teachers to take on the position of supporting the children’s participation.

Other complex efforts involving ICT development for and with children would also be of interest for future study. However, other communities with similar characteristics may be able to utilize these results – even based on this one case – at least by advocating in their development efforts the roles for children discussed in this thesis. Thus, this study may serve as an example case for other communities seeking to enable children’s participation in ICT development efforts.

Moreover, in future research, it may be of interest to continue the discussions of the ethical aspects of children’s participation. Hopefully, the discussions raised in this thesis will contribute to the topic of strengthening children's participation in ICT development.
References


Nishida K (1958) Intelligibility and the philosophy of nothingness. Рипол Классик.


Appendix 1

Appendix 1 illustrates the data from this study.

Table 4. Illustration of the research data.

<table>
<thead>
<tr>
<th>Data</th>
<th>The themes of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews with key actors:</td>
<td>Themes included in the thematic interview guide: background, history, nature of effort;</td>
</tr>
<tr>
<td>2 headmasters [Interviewees 1 and</td>
<td>collaboration among the public, business, and research sectors; building the information</td>
</tr>
<tr>
<td>5], 2 project managers [Interviewees 2 and 3]</td>
<td>infrastructure and technology use; and community aspects and visions on the new town area</td>
</tr>
<tr>
<td>1 development manager [Interviewee 4]</td>
<td>and the multifunction center with the Integrated Pilot School</td>
</tr>
<tr>
<td>Interviews with teachers:</td>
<td>Purchasing process, acquisitions for schools, and user engagement in purchasing (children and adults)</td>
</tr>
<tr>
<td>2 teachers [Interviewees 6 and 7]</td>
<td></td>
</tr>
<tr>
<td>Interviews with and workshops with children:</td>
<td>The themes included: home, school, multipurpose center, community participation, ICT, and themes</td>
</tr>
<tr>
<td>Interviews with 24 children</td>
<td>suggested by the interviewees (i.e. their wishes and expectations concerning the Integrated Pilot School in the multipurpose center)</td>
</tr>
<tr>
<td>Arranged workshops with 15 children: one workshop with 5 children, aged 7–8, and two workshops with 5 children each, aged 9–12</td>
<td></td>
</tr>
<tr>
<td>Documentation:</td>
<td>Issues related to the future school and the information infrastructure building effort</td>
</tr>
<tr>
<td>102 items of background documents, minutes, city web portal pages, project pages, reports, articles, and materials by the schools involved</td>
<td></td>
</tr>
</tbody>
</table>
Original publications


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Original publications are not included in the electronic version of the dissertation.
645. Viitikainen, Maria (2014) Ecosystem-level consequences of climate warming in tundra under differing grazing pressures by reindeer


647. Cherevatova, Maria (2014) Electrical conductivity structure of the lithosphere in western Fennoscandia from three-dimensional magnetotelluric data


650. Shao, Xiuyan (2015) Understanding information systems (IS) security investments in organizations


652. Tolkkainen, Mäkko (2015) Biodiversity and ecosystem functioning in boreal streams : the effects of anthropogenic disturbances and naturally stressful environments


655. Li, Ying (2015) Users’ information systems (IS) security behavior in different contexts


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PARTICIPATION IN INFRASTRUCTURING THE FUTURE SCHOOL. A NEXUS ANALYTIC INQUIRY