Today, children use technology daily and the ways they play, learn and interact with others are changing. It is therefore important to understand how children take part in the design of these technologies. However, involving children in a design process is not without challenges as it can be hard for children and adults to take part on equal terms. For children in special education, additional challenges are introduced which leads to a greater need to provide familiarity, support and structure during design activities.

The aim of this thesis is to contribute to the knowledge on how to involve children in special education in the design process. This has been explored through a two-year long design process in the school context. As design activities are adapted to the practice of school, relationships and mutual understanding stand out as important. These are presented in a model. Early on, the researcher relies on a teacher to facilitate the relationship with children, and to understand the practice. This can affect the design activities as teachers may have different goals and can be unaware of the researcher's desired outcome from the activity. By investing time and building stronger relationships, the researcher can get a better understanding of the practice, allow teachers to align with research goals and enable children to take part in design activities more independently.

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Peter Börjesson Designing for and with developmentally diverse children in the special education context

UNIVERSITY OF GOTHENBURG

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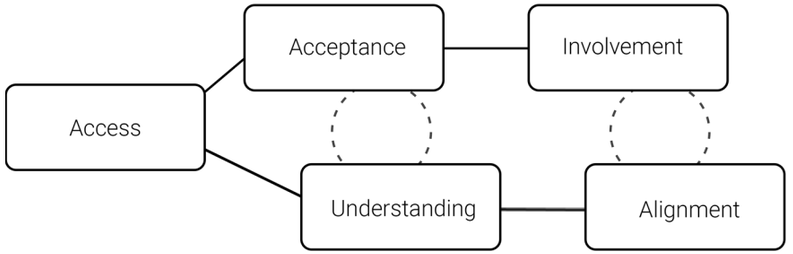

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THESIS FOR THE DEGREE OF LICENTIATE OF PHILOSOPHY

Designing for and with developmentally diverse children in the special education context

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Department of Applied Information Technology

University of Gothenburg, Sweden 2017

DESIGNING FOR AND WITH DEVELOPMENTALLY DIVERSE CHILDREN
IN THE SPECIAL EDUCATION CONTEXT

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Abstract

Nowadays, children use technology every day and as children are growing up with interactive technologies, the ways they play, learn and interact with others are changing. It is therefore important to understand how children can take part in the design of these technologies. However, involving children in the design process is not without challenges as it can be hard to involve children and adults on equal terms. For children in special education additional challenges are often introduced, not only related to the involvement of adults, but around providing familiarity and structure during design activities.

The aim of this thesis is to contribute to the knowledge on how to involve developmentally diverse children in the design process of technology. This has been explored through a two-year long design process taking place in the special education context. Conducting design activities in the children's school, with support of familiar teachers and assistants, help to provide familiarity and structure. As design activities need to be adapted to conform to the practice of school, the relationships and mutual understanding between the researcher and children, and between researcher and teachers or assistants stand out as important.

The thesis presents a model describing the relationships, mutual understanding, and roles that children, teachers, and assistants play during the design process, and the effects this may have on design activities. The D^3iSC model (Designing for and with Developmentally Diverse children in a School Context) consists of five different stages, Access, Acceptance, Understanding, Involvement and Alignment. To gain access, the perceived value of the research must outweigh the costs in terms of the effects on the children's well-being, and to not disturb of the daily practice of the school. Next the researcher need to gain acceptance from children and teachers, and start to build up an understanding of the context. While it is possible to conduct design activities with children at this stage, the researcher will be very dependent on teachers and assistants to facilitate the relationship with children, and to understand the practice. This can affect the design activities as teachers may have different goals and be unaware of the researchers desired outcome from the activity. By investing time and building stronger relationships, the researcher can get a better understanding of practice, allow teachers to align with research goals and enable children to take part in design activities more independently.

Keywords
Children, Developmentally diverse, Special needs, Participatory design, Human-centred design

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Lastly, I want to thank my wonderful wife Sara, for being my best friend and always supporting me, and my two sons Anton and Emil for making sure I wake up every morning.

List of appended papers

Paper 1
Peter Börjesson, Wolmet Barendregt, Eva Eriksson, and Olof Torgersson. *Designing technology for and with developmentally diverse children - A systematic literature review*. International Conference on Interaction Design and Children, 2015

Paper 2
Wolmet Barendregt, Mathilde M. Bekker, Peter Börjesson, Eva Eriksson, and Olof Torgersson. *The Role Definition Matrix: Creating a Shared Understanding of Children's Participation in the Design Process*. International Conference on Interaction Design and Children, 2016

Paper 3
Wolmet Barendregt, Mathilde M. Bekker, Peter Börjesson, Eva Eriksson, and Olof Torgersson. *Legitimate Participation in the Classroom Context - Adding Learning Goals to Participatory Design*. International Conference on Interaction Design and Children, 2016

Paper 4
Peter Börjesson. *Extended participation - Experiences from building relationships for design with developmentally diverse children and their teachers*. Submitted to CoDesign: International Journal of CoCreation in Design and the Arts, 2017

Distribution of work

Paper 1
As the first author, I planned and led the study and did the first round of analysis. All authors took part in the second and third round of analysis and in compiling the results. All authors co-wrote the manuscript. The work was presented by me at the conference.

Paper 2
This paper is based on findings from paper 1, and all authors contributed equally to the analysis and compilation of the results. The first author wrote the main part of the manuscript, while the other authors co-wrote and edited it. The first author presented the work at the conference.

Paper 3
All authors contributed equally in planning the research that was conducted within the course *Design of children's technology*. I was responsible for supervising the students during the project from which the data was gathered. All authors contributed equally in the analysis and compilation of the results. The first author wrote the main part of the manuscript, while the other authors co-wrote and edited it. The work was presented by me at the conference.

Paper 4
All research in the field was carried out by me, but has been part of a larger project with continuous meetings with supervisors. I am the single author of the manuscript, but have received valuable feedback from my supervisors.

Table of contents

1 Introduction

Today, children use technology on a daily basis for playing, learning and communicating (Read and Bekker, 2011). Technology is accessible and ubiquitous and can be found in most objects, from toys and books to games and tablets. It can also be found in a variety of places; at school, at home, in the car or at the store. As children are growing up with interactive technologies, the ways they play, learn and interact with others are changing (Hourcade, 2015). It is therefore important to both design these interactions and to understand how technologies are used by children.

Involving children in the design process of those technologies can be done in a number of different ways. Druin (2002), identified four roles that children can have in the design of technology: users, testers, informants and design partners. Historically, children have mostly been involved as users or testers, brought in towards the end of the design process, with low impact on the technology developed. Today, children are often involved more actively as informants or design partners, in child-centred, or participatory design processes, e.g. (Dindler and Iversen, 2007; Horton *et al.*, 2012). In a content analysis of papers published at the Interaction Design and Children conference between 2002 and 2010, Yarosh *et al*. (2011) showed that many researchers in the community see the design of children's technology as more than just creating an artefact. Children are acknowledged as active agents in the creation of their technology and measures are taken to make sure that the designed technology reflect the children's voices.

However, making children part of the design process comes with a set of challenges, for example the power structures between children and adults (Pardo, Vetere and Howard, 2006; Guha, Druin and Fails, 2013), decision making and transparency (Iivari, Kinnula and Kuure, 2015), and group dynamics between children (Van Mechelen *et al.*, 2015). These challenges can make it harder to involve children and adults on equal terms and have children express their true opinion. However, many methods and approaches have been developed to mitigate these challenges, e.g. Cooperative Inquiry (Guha, Druin and Fails, 2013), Fictional Inquiry (Dindler and Iversen, 2007), Layered Elaboration (Walsh *et al.*, 2010), Mission from Mars (Dindler *et al.*, 2005), KidReporter (Bekker *et al.*, 2003) , Mixing Ideas (Guha *et al.*, 2004), and Comicboarding (Moraveji *et al.*, 2007).

Lately, researchers have also started to include children with special needs more actively in the design of technology, e.g. Piper *et al*. (2006), and Benton *et al*. (2012). These and other researchers, point out that including children with special needs introduces additional challenges, for example the involvement of adults and communication between children and adult researchers (Benton *et al.*, 2012; Holone and Herstad, 2013), and the balance between empowering and overburdening the children during design activities (Frauenberger, Good and Keay-Bright, 2011). As for their typically developed peers, a number of methods and approaches have been developed or adapted to enable children with special needs to take part in the design process, e.g. Children in the Centre framework (Kärnä *et*

al., 2010), Cooperative Inquiry (Foss *et al.*, 2013), Diversity for Design (Benton *et al.*, 2014), Narrative-based elicitation (Malinverni *et al.*, 2014), and Experience centred design (Durrant *et al.*, 2013). The group of children with special needs that has received the most attention in recent years are children diagnosed with autism spectrum conditions (Börjesson *et al.*, 2015; Hourcade, 2015), for example in work by Porayska-Pomsta *et al*. (2011), Benton *et al*. (2012), Hourcade, Bullock-Rest and Hansen (2012), and Malinverni *et al*. (2014).

1.1 Scope and purpose of thesis

The research described in this thesis aims to build upon and extend the knowledge on including children with special needs in the design of technology. It does so by designing technology to support social and emotional development, together with children and teachers in compulsory school for children with learning disabilities in Sweden (Skolverket, 2014b). In the following sections, this school form, the target group and the research project will be described, leading up to, and explaining the scope and purpose of the thesis.

1.1.1 Compulsory school for children with learning disabilities

Compulsory school for children with learning disabilities is a form of education adapted to children who are assessed as being unable to meet the knowledge requirements of the regular compulsory school in Sweden (Skolverket, 2014b). It is designed to give intellectually challenged children with developmental disabilities, or long-term cognitive disabilities owing to brain damage, an education that is adapted to their individual capabilities (Skolverket, 2014a). The curriculum includes education in specific subjects that should as far as possible match that of the regular compulsory school. Besides providing knowledge and values it should also contribute to personal development and social togetherness. The number of children in each class is often smaller compared to compulsory school for typically developing children, and more adult support is available in the form of assistants. There is also a special orientation called training school for children with more severe learning disabilities, who are deemed unable to benefit from studying specific subjects. In training school, the education instead focuses on five subject areas; aesthetic activity, motor skills, communication, everyday activities, and reality perception (Skolverket, 2014b).

To be entitled to attend compulsory school for children with learning disabilities, an enquiry is carried out, comprised of four different assessments; pedagogical, psychological, medical, and social. The objective is to ascertain that the child has an intellectual disability, the extent of the disability, and if there are any medical or social factors that contribute to the child's learning difficulties (Skolverket, 2014b). During the school year of 2014/15, 9700 children attended compulsory school for children for with learning disabilities, and more than a third of them, 3800 attended training school (Skolverket, 2016).

1.1.2 Defining a target group

While the term 'children with special needs' is loosely used above, the use of this and similar terms is not without problems (Pontual da Rocha Falcão, 2014). Many of them are rather broad and require understanding of context or further details to be properly understood. 'Children with special needs' could for example refer to children who are blind, deaf or have a physical impairment, but also to children with an intellectual disability. 'Children with special educational needs' is used in the United Kingdom to refer to children who have significantly greater difficulties affecting learning, behaviour, emotional and social development, communication, ability to care for self and gain independence, compared to their typically developing peers (Pontual da Rocha Falcão, 2014). In Sweden, however, special schools are for children who are e.g. deaf, blind, have serious speech impediments and cannot attend other compulsory school forms (Skolverket, 2014a).

Some terms also have rather negative connotations, as an example Intellectual disability, used to be called 'mental retardation' by the American Psychiatric Association up until the release of Diagnostic and Statistical Manual of Mental Disorders, DSM-V (2013). In the revised version of the manual an Intellectual disability or (Intellectual developmental disorder) is described as an impairment of general mental abilities that impacts adaptive functioning in three domains:

- The conceptual domain includes skills in language, reading, writing, math, reasoning, knowledge, and memory.
- The social domain refers to empathy, social judgement, interpersonal communication skills, the ability to make and retain friendship, and similar capacities.
- The practical domain focuses on self-management in areas such as personal care, job responsibilities, money management, recreation, and organising school and work tasks.

It is also stated that while an intellectual disability does not have an age requirement, the symptoms must begin during the developmental period. In addition, it describes that the disability is chronic and often occurs together with other mental conditions, e.g. depression, autism, and attention-deficit/hyperactivity disorder (ADHD) (American Psychiatric Association, 2013).

Even within a national context, different terms can be used to talk about the same target group. As stated above, in Sweden, the school form for children with 'developmental disabilities' is called compulsory school for children with 'learning disabilities'. However, in the Swedish education act from 2011 it is now stated that children with autism who are not 'intellectually challenged' no longer belong to the target group for this school form. Therefore, in Sweden, children in compulsory school for children with learning disabilities (Skolverket, 2014b) all have an intellectual disability, but as described in DSM-V (2013), are also often diagnosed with for example autism or ADHD.

In order to be more precise, and trying to avoid a negative connotation, this thesis will refer to children in Swedish compulsory school for children with learning

disabilities using the term 'developmentally diverse children'. This is a combination of the terms 'developmental disability', a condition attributable to a mental or physical impairment, that originates before adulthood and is expected to continue indefinitely (U.S. Department of Health & Human Services, 2016), and 'neurodiversity', a term coined by Singer (1999), a sociologist and autistic rights advocate to indicate that neurological conditions appear as a result of normal variations in the population and should be seen as 'another state of being' (Dalton, 2013). Over time, this movement has grown and now includes a number of conditions besides autism and Asperger syndrome, e.g. dyslexia, dyscalculia, dyspraxia, Tourette's syndrome and attention deficit hyperactivity disorder (ADHD). Neurodiversity as a movement has been criticized (Jaarsma and Welin, 2012), pointing out that while high-functioning autistic people may benefit from not being stigmatised, low-functioning autistic people may actually benefit from being recognized as vulnerable and disabled. However, as pointed out by Benton *et al*. (2014), in design the perspective offers a new way of thinking about the involvement of neurodiverse people, recognizing that they have strengths alongside the deficits that otherwise often define them. Besides the point made by Benton *et al*. above, the term developmental diversity is also used to indicate that the focus is not on children with one specific disability, but rather on heterogeneous groups of children where different developmental disabilities occur and co-occur among the children.

1.1.3 Research project

The research presented in this thesis has been carried out within the scope of the Touch-AT! project[1]. The aim of the project is to first identify needs for different touch-based technologies for social and emotional development, and then design those technologies together with children and teachers in compulsory school for children with learning disabilities. Another aspect of the project is to investigate how the children and their teachers can be participants in, and contribute to, the design process, from requirements gathering and ideation to design and evaluation.

The focus of this thesis is mainly on the involvement of children, teachers, and other adults in the design process, and how relationships and interactions between participants affect the design process. The focus on social and emotional development is used to delimit the type of technology design to focus on, but the research is more focused on the design process at large.

1.1.4 Research questions

(1) What factors can be identified that affects the choice of approach or methods when involving developmentally diverse children in a design process in the school context?
(2) What roles do developmentally diverse children, their teachers and other adults play during the design process of technology for developmentally diverse children in the school context?

[1] touch-at.se

2 Background

The research described in this thesis falls within the tradition of research through design, human-centered design, and participatory design. As it involves designing for and with children, it is also part of the child-computer interaction research field in general, and more specifically concerns the involvement of developmentally diverse children in the design process. This section will describe these research areas, and will additionally exemplify how social and emotional skills can be taught and how technology can support this.

2.1 Research through design

Based on Frayling's distinctions between research *into* art and design, research *through* art and design, and research *for* art and design (Frayling, 1994), Zimmerman, Stolterman and Forlizzi (2010) have characterized two types of design theory, theory *on* design, and theory *for* design. Theory for design is developed with the intention of improving the practice of design, while theory on design is developed to understand the activity, how and why people design. They also say that the approach of research *through* design can lead to theory for design and possibly theory on design.

Zimmerman, Forlizzi, and Evenson (2007) proposed a model for research through design within the human-computer interaction field. In this model, designers engage with wicked problems and integrate both *true* knowledge and *how* knowledge. The *true* knowledge comes from models and theories in behavioural science, while the *how* knowledge comes from technical opportunities in engineering. The design research is then grounded in *real* knowledge, produced by anthropologists and design researchers in upfront research for a specific project.

Four criteria or lenses were also suggested to be use when evaluating research through design; *process*, *relevance*, *invention* and *extendibility* (Zimmerman, Forlizzi and, Evenson, 2007). The *process* needs be documented in enough detail to be reproduced, and one should be able to determine the rigor in applying methods and the rationale behind them. Even though the process should be reproducible, no one expects two designers to produce the same or even similar artefacts when given the same problem. Based on that, *relevance* shifts the focus from validity or what is true, to what is real and how a solution works in a given context. In addition, researchers need to articulate the preferred state the design attempts to achieve, and motivate why this state should be preferred. They also state that the contribution should be a significant *invention* and that research must show how the contribution advances the research community. Lastly, *extensibility* means that the research should be described and documented in ways that allow the community to build upon the produced knowledge.

In an overview of research through design (Zimmerman, Stolterman and Forlizzi, 2010), it is described that while there are some disagreements about what research through design is and how it should be conducted, there seems to be consensus that the focus is on creating an artefact aimed at societal change or seeking a

preferred state. Wicked problems that are often at the centre of design research are recognized as unapproachable by traditional scientific methods. The aim of solving a wicked problem is often to find the best possible solution given the practical limitations of the context, rather than the discovery of truth (Zimmerman, Stolterman and Forlizzi, 2010). Therefore, the designed artefact is an important outcome in research through design, and seen as a proposition for the preferred state, or as a placeholder that opens new design spaces. Other outcomes of research through design processes include methods and theories.

2.2 Human-centred design

Human-centred design (HCD) is concerned with incorporating the users' perspective in the design of technology to produce usable systems as a supplement to technical and functional requirements (Maguire, 2001). According to Maguire there are four key principles in HCD:

- The active involvement of users and a clear understanding of user and task requirements.
- An appropriate allocation of function between user and system.
- Iteration of design solutions.
- Multi-disciplinary design teams.

The ISO 13407 standard that defines HCD (ISO, 1999), lists five activities or phases in the human-centred design cycle, see Figure 1. These phases are essential to incorporate usability requirements in the design and development process and are carried out iteratively until the usability requirements have been met (Maguire, 2001). For each of the phases, several methods are associated that support the objectives of that phase, e.g. field studies and user observations to understand the context of use, interviews and focus groups to collect requirements, brainstorming and prototyping during design, and heuristic or expert evaluation during the evaluation phase (Maguire, 2001).

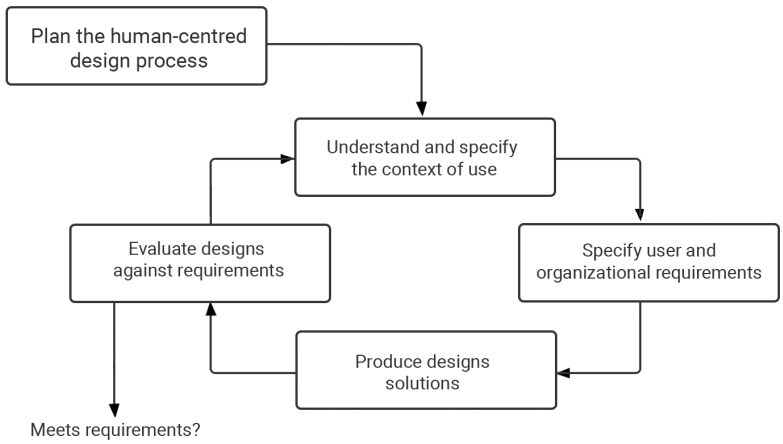

Figure 1: The human-centred design process *(ISO, 1999)*.

Another way to describe human-centred design comes from the global design company IDEO. In their Field Guide to Human-Centered Design (IDEO, 2014), they state that human-centred design is based on the beliefs that all problems are solvable, and that the people who face those problems every day hold the key to solve them. The process is also described differently with three phases: Inspiration, Ideation and Implementation. In the inspiration phase, empathy and understanding are built up for those the design is for. During ideation, it is time to make sense of everything from the inspiration phase, and generate tons of ideas, identify opportunities for design and test and refine different solutions. During implementation, ideas are brought to life, and brought to market to maximise the impact in the world (IDEO, 2014).

2.3 Participatory design

While in human-centred design, the focus is on incorporating the users' perspective into the design process, Participatory Design (PD) is committed to involving users in genuine participation (Robertson and Simonsen, 2013). Genuine participation goes beyond just involving users as informants that provide answers to questions, rather they are involved as legitimate and acknowledged participants in the design process. An important pillar of PD is to work with values. As Iversen, Halskov, and Leong (2010) put it: *"in PD, participation is about values […] in that the people whose activity and experiences will ultimately be affected most directly by a design outcome ought to have a substantive say in what that outcome is"*. This involvement is based on a set of fundamental aspects, described in a review of contemporary PD research (Halskov and Hansen, 2015), as:

- People who are affected by a decision should have an opportunity to influence it.
- People play critical roles in design by being experts in their own lives.
- The use situation is the fundamental starting point for the design process.
- Design methods are means for users to gain influence in design processes.
- The goal of participation is to design alternatives, improving quality of life.

These aspects are also echoed by Robertson and Simonsen (2013), explaining that PD seeks to enable those who will use technology to have a voice in its design. While 'value' refers to the value of something, 'values' refers to what is important in life (den Ouden, 2012), and gives therefore a more holistic view. In a design context where the designers aim to provide value through transformations, both 'value' and 'values' are important, since the product itself should not only be of value to stakeholders, but it should also contribute to their values. Furthermore, the involvement in the design process itself could also be valuable.

The different stakeholders in a design process thus need to engage in mutual learning processes. Designers must learn about the users, their values, practices, and use situation, while users need to learn about the designers' values, what is possible in terms of technology, and how these possibilities can be provided. By using different methods, tools, and techniques, the aim is to create hybrid experiences, a third space between users and designers in which they combine diverse knowledge into new insights (Muller and Druin, 2012)

The context in which technology will be used is important for PD in many ways. As pointed out by Halskov and Hansen (2015), the use situation is the fundamental starting point for the design process. Similarly, Robertson and Simonsen (2013) state that understanding practice, what people really do, is fundamental to PD both to inform design but also to understand how the designed artefact will shape how practices change. Therefore, ethnographic methods are important to get an experiential understanding of actual practice.

2.4 Designing for and with children

The values of both human-centred and participatory design described above, resonates well with those present in child-computer interaction. As shown by Yarosh *et al*. (2011), the community around the Interaction Design and Children conference, sees children as active agents in the technology design process, and it is considered important that children's voices are reflected in the designed technology. This is also reflected in one of the pillars of child-computer interaction (Hourcade, 2015); to deeply engage with stakeholders and involve children throughout the design process, in the context and practices where the technology will be used.

When designing for children it is important to remember that children are not just small adults. Read and Bekker (2011), identified some key differences between the field of Human Computer Interaction (HCI) and Child Computer Interaction (CCI); the rate of change of children, the context in which children use technology, the involvement of adults in children's interactions, and the underlying cultural and societal assumptions about technology and children. Children's change rate relates to their development and the abilities they acquire in this process. Besides the physical differences between children and adults, one must also consider cognitive abilities, e.g. memory, processing abilities, and, reading skills. These abilities also vary greatly between children of different ages (Read and Bekker, 2011), and it can therefore be important to understand existing research on child development when designing for children (Hourcade, 2015).

Children use technology in a different context and for different reasons than adults (Read and Bekker, 2011). For children, technology is generally used for playing, learning or communication. When using technology, children want to be in control, have social experiences, and use it as an expressive tool (Druin *et al.*, 1998). Associated with this comes a different set of criteria of what is seen as important in technology. For example, fun and playability can be more important than ease of use, e.g. efficiency and effectiveness (Read and Bekker, 2011; Hourcade, 2015).

In design for children it is also important to consider adults (Read and Bekker, 2011). Adults often determine what technologies children will use, and this decision is rarely based on usability or suitability, but rather on marketing hype, peer pressure, or cultural and societal assumptions related to children and technology use. In addition, adults are often affected by the technologies that children use, and may assist them in using those technologies.

While it can be important to also involve adults in the design process, it is crucial to realize that adults are not a replacement for children (Hourcade, 2015). Adults do not only have a hard time remembering how it was to be a child, but in addition, being a child today is different from being a child 20 or 30 years ago. New generations grow up with new expectations, experiences, needs and interests, and are experts on what is its means to be a child today (Guha, Druin and Fails, 2013; Hourcade, 2015). When adults act as proxies for children there is also a risk, even with the best intentions, they think of their own needs, rather than the needs of the children (Guha, Druin and Fails, 2013).

2.4.1 Children's roles in the design of technology

Druin (2002) identified four roles that children can have in the design of technology; users, testers, informants, and design partners. The role in which children are involved can depend on e.g. research or development goals, available resources or time, and the philosophy of researchers involved. While there are distinctions between these roles (described below), each role contains elements of the underlying role, i.e. when being involved as informants, children may be asked to test technology. Druin also presents three underlying dimensions that define these roles; the relationships to adults, the relationship to technology and the goals for the inquiry (see Figure 2). In addition to Druin's framework, this section will also present other models and frameworks for understanding and describing children's role in design of technology.

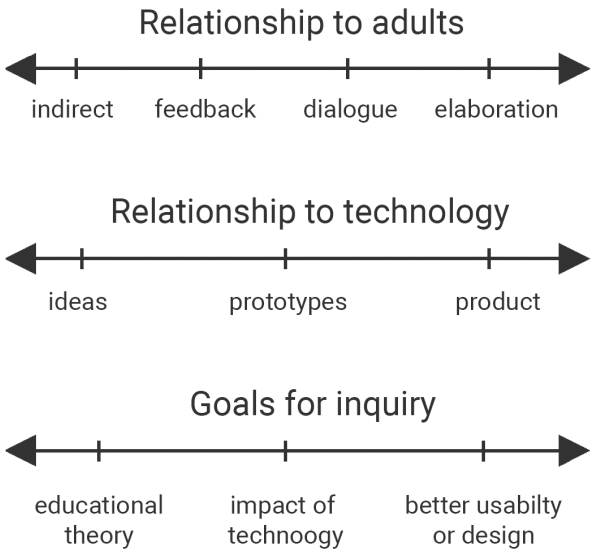

Figure 2: The underlying dimension to each role described by Druin *(2002)*

Children as users

When children are involved as users, the goal for inquiry is often to understand children's activities with different technologies (Druin, 2002). This can both inform future technology development, and help with understanding the process of learning connected to the technology. As the technology used in this stage is typically already developed and distributed, the children have no impact on the design of the technology. The relationship to adults is often indirect, and children are often just observed using the technology.

Children as testers

The role of tester is similar to the role of user but can be differentiated by the underlying dimensions (Druin, 2002). As testers, children are involved while the technology is still being designed to test prototypes, rather than finished products. In this role, children have more impact on the tested technology, as the goal for inquiry is often to create a better and more usable design. As testers, the children are once again observed using the technology, but in addition asked for feedback about the experience.

Informant design framework

In informant design presented by Scaife *et al*. (1997), it is recognized that there is a value in including children in the design process and that the involvement should go beyond that of users or testers of technology However, Scaife *et al*. question whether it is sensible or desirable to include children with equal responsibilities to adults in a design team. Further, they also ask if children can make contributions about the educational content and the way it should be taught. In the informant design framework, children and other domain experts are brought in at various stages throughout the design process to maximize the diversity of the input (Scaife *et al.*, 1997; Scaife and Rogers, 1998). The idea is that different experts e.g. children and teachers can contribute with different input and that some input is more needed in some phases compared to others, and are elicited through different methods and techniques. Druin describes that as informants, children can be involved in numerous ways during the design process. The goals for inquiry is often related to a better understanding of technology and better design. As informants, children are also given the opportunity to take part in a dialogue around the technology, besides being involved indirectly or just being asked for feedback.

Design partnering

With children involved as design partners, the elaboration of ideas between children and adults is seen as a crucial component. In this role, children are involved throughout the design process as equal stakeholders. In order to accomplish this, an important component is to remove all existing power structures between children and adults. As shown above, whether or not this is possible has been questioned, for example by Scaife *et al*. (1997), Scaife and Rogers (1998), but also by Large *et al*. (2006). In design partnering it is acknowledged and agreed that these power structures exist, but that they can be overcome (Guha, Druin and Fails, 2013). This takes time, but can also be supported by techniques, e.g. using informal language, wearing informal clothes, not raising hands, using first-names only, and sitting on

the floor together. The design partner role can be hard to live up to, as it is described as a long-term agreement, a tenure, where it can take months to become a true design partner (Guha, Druin and Fails, 2013). One problem with Druin's model is that design partnering is the only viable alternative to the informant role when describing children's involvement in the design process beyond the role of tester (Barendregt *et al.*, 2016), and alternative models are described below and in Paper 2 included in this thesis.

IBF Model

The informant-balanced-facilitated design (IBF) model, can be used to understand the role and contribution from children in the design process (Read *et al.*, 2002). A distinction is made between domain experts (children) and design experts (academics). The contribution of children is considered on a continuum, from informant design to facilitated design. In 'Informant design' the domain experts have limited impact on the design, and are mostly brought in to the process to inform design experts that then realize the ideas. In 'Facilitated design' the emphasis is on the domain experts to both initiate and realize the idea, with design experts being facilitators. In balanced design, there is an equal partnership between domain experts and design experts. In addition, the IBF model identifies four factors that influence where on the continuum a group of children may end up. *Skills* and *environment* have an initial effect on the participants and are quite static during an activity, while *knowledge* and *security* can fluctuate over an activity and change the group's position on the continuum.

Bonded design

In bonded design, children's role in the design process is somewhere between that of design partners and informants (Large *et al.*, 2006). It emphasizes the importance of an intergenerational design team and holds a conviction that children should play an active role in the design of technology. At the same time, it shares the reservations of the informant design framework and questions to what extent children can be involved as equal stakeholders.

2.4.2 Design methods and techniques for involving children in design

There are a number of methods available for involving children in the design process, of which some are also used with adults, e.g. observations, brainstorming, and interviews, while others are developed specifically for children. This section will look closer at some of the available specific methods for including children in the different phases of the design process.

Requirements gathering

As conventional, a design process for children starts with the collection of requirements. This is often done by observations or by engaging with children in different activities (Hourcade, 2015). Two types of activities that can be used in this phase are contextual inquiry and technology immersion, that are part of the Cooperative Inquiry method (Druin, 1999).

In technology immersion, children can familiarize themselves with novel technology which can capture activity patterns, that may otherwise be missed (Druin, 1999). In recent years, the results of technology immersion are described as less helpful in relation the time invested in most circumstances (Guha, Druin and Fails, 2013). One possible explanation could be that many children have access to a lot of technology at home or in school.

Contextual inquiry was originally devised for adults (Beyer and Holtzblatt, 1998), but adapted when used in Cooperative Inquiry (Druin, 1999). In this activity, children are researchers along with their adult partners and observe and interact with other children to collect data. Data from children is often collected by drawings annotated with small amounts of text, while adults usually rely on text only. During observations, there is often an interactor that engages with the child and asks questions about the activity.

It can be hard for children to communicate both about existing practices and contexts, as well as about future scenarios. To address this problem, Dindler and Iversen (2007) suggest using Fictional Inquiry. By using a narrative, designers can bypass existing socio-cultural structures, allowing them to ask odd questions, or open up future possibilities without considering the limitations of today. One example of using Fictional Inquiry with children, is Mission from Mars (Dindler *et al.*, 2005), where children are asked to communicate with an alien, and tell the alien about different aspects of their lives.

Design

During the design phase, children are often involved in different design activities to create low-fidelity prototypes. In Cooperative Inquiry, children and adults use different participatory design techniques, e.g. Bags of Stuff, Big Paper, and Sticky Noting (Guha, Druin and Fails, 2013). With Bags of Stuff, children are presented with different materials, e.g. pens, paper, scissors, strings, cardboard, glue, etc. to sketch and create low fidelity prototypes. In Big paper, numerous children can brainstorm together on a large sheet of paper, allowing them to more easily collaborate and elaborate on each other's ideas. Sticky Noting is a way to critique prototypes or existing technology by writing down likes, dislikes and things that can be improved on sticky notes.

When working with low-fidelity prototypes, idea elaboration can be challenging. A design technique that can help with this is Layered Elaboration (Walsh *et al.*, 2010). Layered Elaboration allows children and adults to elaborate and build on each other's ideas and sketches, while leaving the original idea intact, by using transparent materials as overlays.

Children involved in design are often between 7-11 years old (Yarosh *et al.*, 2011). One possible explanation for this is that children in this age are verbal and self-reflective enough to discuss ideas, and at the same time not self-critical and burdened with a notion of how things ought to be (Druin *et al.*, 1998). When involving children in other age groups Guha, Druin and Fails point out that they have may have unique needs (2013). For example, older children may need more guidance in

using low-fidelity prototyping, while younger children may need more support to work collaboratively. To support the latter the technique Mixing Ideas (Guha *et al.*, 2004) can be used, to combine different individual ideas into one big idea. Another technique that can be used is Comicboarding (Moraveji *et al.*, 2007). The children are presented with a story in a comic book format where important parts are left out, and then paired with an artist that can help the children fill in these blanks. The method can provide children with scaffolding during brainstorming, and has been successful in generating ideas with children of various backgrounds.

Evaluation

Throughout the design and development children are often involved in informal evaluations of requirements, design ideas, and prototypes (Hourcade, 2015). The informal feedback from children can be collected in a number of ways, e.g. observations, interviews, or Contextual Inquiry.

In more formal evaluations, usability testing is the most common way of involving children. Hanna, Neapolitan, and Risden (2004), when evaluating games, found that involving children who knew each other in pairs, without an observer present provided the most reliable and informative feedback. They also recommended separating concepts and visual art in the game, i.e. to read simple descriptions of concepts and ask children to rate them before seeing the related art. After testing the game, and seeing the art, the children should be asked to re-rank the concepts and discuss likes and dislikes. Höysniemi, Hämäläinen and Turkki (2003) developed a specific evaluation method for pairs, called “peer-tutoring”, where one child is asked to explain the evaluated technology to a peer.

However, evaluation sessions in pairs may not always be the most effective form of evaluation. In a comparative study of social and individual usability methods, (van Kesteren *et al.*, 2003), it was found that children participating in co-discovery together did not cooperate during the test, and sometimes became competitive. The study found that Involving children in peer-tutoring worked better. For individual usability methods, retrospection, and think-aloud worked well, but most verbal feedback was obtained when the researcher actively asked for feedback during the test. For self-reporting, some popular tools are included in the Fun Toolkit (Read and MacFarlane, 2006). The toolkit contains a Smileyometer, a five-step scale with smileys to measure experiences from awful to brilliant, a Fun Sorter to rank things against each other, and the Again-Again Table that can be used to learn whether or not children would like to do something again.

2.5 Designing for and with developmentally diverse children

While the section above discussed roles and methods to involve children in the design process, this section discusses specifically what is known about involving developmentally diverse children in the design process. The text in this section will be largely based on a literature review examining the involvement of developmentally diverse children in the design of technology. This literature review was published at the IDC conference and is included in this thesis as Paper 1. However, in this section the main results needed as a background for this thesis will be presented.

As described in the previous section it has become quite common to include typically developing children in the design process. However, the literature review (Börjesson *et al.*, 2015) revealed that developmentally diverse children are still not as actively involved as their typically developing peers. Nevertheless, over the last decade, there has been an increasing trend of involving developmentally diverse children in the design process. While doing so, there is a tendency to focus on involving children with certain disabilities in isolation, such as high-functioning autism (50%), or low-functioning autism (14%). Children with Down syndrome (2%) or an Intellectual disability (2%) are rarely involved in the design process. Involving groups of children with a mix of disabilities, as in this thesis, occurs in 13% of the cases.

For developmentally diverse children, adults typically play a very prominent role. For example, Holone and Herstad (2013) found that children with severe cognitive, sensory and motoric disabilities are often very dependent on adults to be able to communicate or to carry out certain tasks. The dependency on adults is also evident when involving children with less severe disabilities; e.g. in their work with children with Asperger syndrome, Piper *et al*. (2006) invited parents to sessions to help calm their children if needed, and Benton *et al*. (2012) found that the involvement of a familiar teacher helped reduce the children's anxiety during sessions. In the latter case, the teacher also helped with discouraging negative behaviour, incorporating the children's interest into the design activities, and prompting for design ideas. Our literature review identified four roles that adults typically play in the design process with developmentally diverse children: users, proxies, experts, or facilitators. In the first role, they are recognized and involved as users of the developed technology, even if children are the main target group. In the role of proxy, an adult speaks of behalf of a specific child, while an expert speaks based on their expertise on behalf of a group of children in general. When adults are involved as facilitators, they can help build the relationship between children and researcher, or assist during design activities.

The challenges related to involving adults, already mentioned for typically developing children are often more prominent when involving developmentally diverse children. There is a risk that adults misinterpret or simplify the input from the child, possibly coloured by what they assume the child wants or can contribute with (Holone and Herstad, 2013). Additionally, the power structures between adults and children are even more unbalanced as developmentally diverse children are not accustomed to taking decisions as active participants (Frauenberger, Good and Keay-Bright, 2011; Holone and Herstad, 2013)

2.5.1 Roles and design approaches for developmentally diverse children

The literature review showed that when involving developmentally diverse children in design, many researchers claim to follow a participatory or user-centered design approach. Children are typically involved in several design phases, although it is uncommon for them to be involved throughout the design process. Furthermore, only few researchers explicitly consider the children to be informants or design partners. This could be related to the level of direct influence the children had during

the design process. Indeed, several papers mention the difficulty of involving developmentally diverse children as design partners, e.g. (Keay-Bright, 2007; Menzies, 2011).

In addition, our literature review found a number of approaches specifically developed or adapted for involving developmentally diverse children in the design process. Some of these will be presented below, together with a few other approaches that were identified but not included in the literature review.

IDEAS (Benton *et al.*, 2011, 2012) is a design approach for involving children with autism in the design process. It is specifically designed to help these children overcome the difficulties that may prevent them from taking part in the design process, e.g. difficulties with the concept of meaning, concrete vs. abstract thinking, combining or integrating ideas, organizing and sequencing, generalization, strong impulses, and excessive anxiety. Each session includes a high ratio of adults, both researchers and teaching staff. To help children understand the structure of individual sessions, a visual schedule is provided where children can check off tasks as they are completed. The approach also helps children with understanding the overall structure of the design process as each session starts with a recap of the team rules and a visual recap of previous sessions. To reduce distractions, the sessions should be held in a quiet environment and be designed to be engaging. Additionally, to reduce anxiety and strong impulses the sessions should be carried out in a familiar environment, such as the school, involve familiar adults e.g. teaching staff, and the session structure should be consistent and undertaken at the same time and place each week.

Diversity for Design (Benton *et al.*, 2014) is a framework that can help inform Participatory Design methods aimed at supporting a neurodiverse population to take part in the design process, (see Figure 3). Benton *et al*. argue that in order to provide a design environment that supports collaboration and creativity for these children, one must structure the environment and provide supports. This should be informed not only by each participating child's strengths but also by characteristics of the neurodiverse culture.

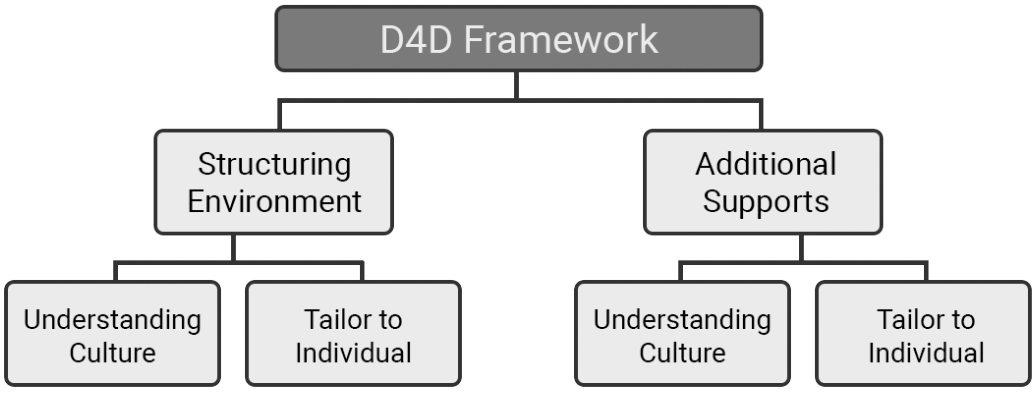

Figure 3: The Diversity for Design Framework (Benton *et al.*, 2014)

Narrative-based elicitation (Malinverni *et al.*, 2014; Mora-Guiard, Malinverni and Pares, 2014) is an approach that makes use of Fictional Inquiry (Dindler and Iversen, 2007), to create a backstory for a game. This backstory is linked to design requirements defined together with psychologists, e.g. being introduced to the environment, developing a relation with the virtual agent, start playing together with a familiar adult, to eventually start playing and socially interacting with an unfamiliar child. The backstory contains a number of narrative elements supporting these requirements, like meeting the main character, building a relationship, help the main character to build and fuel his spaceship, finding his friend, and eventually traveling back to his planet. Each session is supported by a chapter in the backstory, as well as a scene card describing where the events are taking place. The narrative is also supported by ending each session with a cliff-hanger in which the main character is confronted with a turning point in the story, creating a feeling of suspense and triggering the children's curiosity.

Experience-centred design (Durrant *et al.*, 2013) shares values with participatory design but is grounded in observed, tacit, and phenomenological understanding of a context. It puts special emphasis on fostering empathy and aesthetic engagement between stakeholders. In contrast to participatory design it allows designers to design for a community based on the understandings gathered by this empathic aesthetic engagement. In their project, Durrant *et al*. explored different aspects of photography, ranging from how it was currently used to exploring technical aspects and the creative practice surrounding photography.

Cooperative Inquiry (Druin, 1999; Guha, Druin and Fails, 2013) is originally an approach for design partnering with typically developing children, visiting a research lab over a long period of time. However, Foss *et al*. (2013) used an adapted version of the approach together with a group of developmentally diverse children. The adaptations made include adjusting the adult to child ratio, involving adult stakeholders, being flexible in applying methods, and assessing and adapting to individual needs. Additionally, the approach was applied in a classroom setting, rather than a lab, and the design partnership was significantly shorter than described for typically developing children.

The Inclusionary Model (Guha, Druin and Fails, 2008) is a model of how children with special needs can be involved in the design process, consisting of three layers; the level of involvement, the nature and severity of the disability, and the availability and intensity of the support. At the first level, researchers decide how much involvement the children should have in the design process. Here considerations include access to children and available time and funds. At the next level, the child's disability is considered, which may suggest a more limited role in the design process. At the last level, support that may help the children overcome the difficulties identified at the previous level are considered which may open up possibilities for a more active role again.

The Children in the Centre Framework (Kärnä *et al.*, 2010) emphasize the active role of children and their families in the research and design process. It does so by putting the children's interests, strengths and needs at the centre of attention, while still acknowledging possible limitations. By doing so the framework aims to strengthen the bottom-up influence in special education and technology development, which often relies on a top-down approach. The model consists of five layers, see Figure 4.

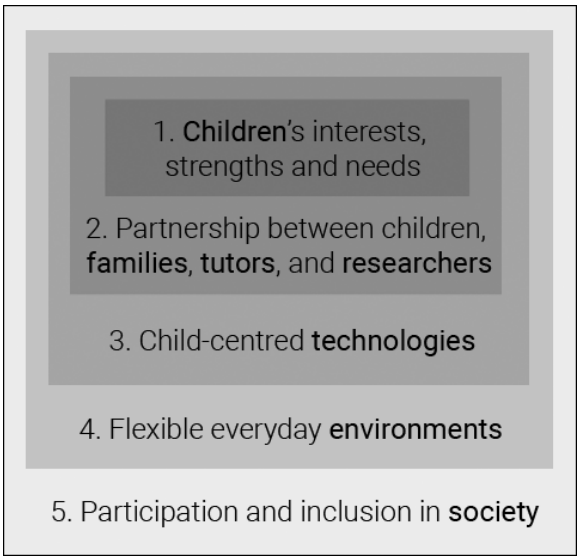

Figure 4: The Children in the Centre Framework developed by Kärnä *et al*. (2010)

At the centre of the framework, the child's interests, strengths and needs, form the basis for all other activities. Level 2 explains that children, their families, tutors and researchers work together during activities. At level 3, it is described that child-centred technologies are a result of the design and development process. Level 4 points to the fact that not only the physical environment but also the technology needs to be flexible and accommodate to the children's and their families' needs. Level 5 binds it all together, stating that the more levels 1-4 have been fulfilled, the more opportunities children and their families have to participate in society.

2.5.2 Design methods and techniques for involving developmentally diverse children in design

In addition to the more overarching approaches described above, our literature review (Börjesson *et al.*, 2015) also identified a number of methods and techniques for involving developmentally diverse children in the different phases of the design process. This section will look closer at some of these methods.

Requirements gathering

When developmentally diverse children are involved in the requirements gathering phase this is usually done as a field study or an observation of the children. In this phase, there is often an implicit additional goal to build a relationship with the children. Building a relationship with the children is often acknowledged as important to establish trust and communication (Holone and Herstad, 2013).

Familiarization activities are undertaken to e.g. be accepted by the children and avoid future unwanted distraction (Keay-Bright, 2012). This can however take a lot of time, for example Piper *et al*. (2006) spent months to build rapport with the children, to allow them to feel comfortable and avoid overstimulation in the new situations introduced during the design process.

Observations can be both natural observations (Durrant *et al.*, 2013), for example taking place during the children's school day, as well as activities instigated by the researchers. For example, Hourcade, Bullock-Rest, and Hansen (2012), used a method called visits and demos both with lower and higher functioning autistic children. When working with lower functioning children the researchers let the children explore the applications and observed how they responded to them. With the higher functioning children the applications were also discussed (Hourcade, Bullock-Rest and Hansen, 2012). In a similar vein, Frauenberger, Good, and Keay-Bright (2011) created a number of methods to explore how children experience different objects and their properties. One of these is the Odd-one-out method in which children are given four different objects and asked to explain by drawing or writing, which object does not belong with the others. The authors also used a method called The Comic, drawing inspiration from e.g. Comicboarding (Moraveji *et al.*, 2007), in which children are provided with the start and end of a comic, and asked to incorporate a special object provided to them.

Sometimes children are involved in user requirements interviews (Brederode *et al.*, 2005; Piper *et al.*, 2006), or focus groups (Nazneen *et al.*, 2010; Garcia *et al.*, 2013). Piper *et al*. (2006) reported on facing problems with performing individual interviews as children felt uncomfortable. Switching to group interviews with four to five children worked better. When involved in focus groups children are either involved with other children (Garcia *et al.*, 2013), with a familiar adult, for example a parent (Nazneen *et al.*, 2011), or within a group of experts, e.g. therapists and developers (George and Gnanayutham, 2007).

Design

During the design phase, developmentally diverse children are sometimes involved in creative sessions using methods like Big paper, Bags of Stuff, Mixing Ideas and Storyboarding (Foss *et al.*, 2013), or Fictional Inquiry techniques (Malinverni *et al.*, 2014). However, it is more common that children are involved in informal evaluations and provide feedback on a prototype with varying levels of active involvement. Their involvement can range from just being observed (Keay-Bright, 2007), to taking part in specific activities e.g. 'lunch bunches' (Hourcade, Bullock-Rest and Hansen, 2012), in which the prototypes are tested together with peers. Another method used in the design phase is experience prototyping (Keay-Bright and Howarth, 2011). Here, the focus is not on evaluating a prototype, but rather on enabling children to contribute to the design by interacting with the prototype to show their interests. In Scenario Design (Millen, Cobb and Patel, 2011), children with autism are involved in a series of structured activities in the design of a game. The method was adapted from previous scenario design sessions with typically developing children by making the activity more structured, using templates and concrete materials, and letting the children draw on a outlined screen instead of a blank piece of paper.

Evaluation

In the evaluation phase, developmentally children are often involved in usability testing, with varying levels of activity. When children are given the chance to provide feedback during or after usability testing, the feedback is collected by e.g. Verbal questioning (Wu *et al.*, 2003), Questionnaires (Benton *et al.*, 2012), Critique sessions (Durrant *et al.*, 2013), Feedback sessions (Zarin and Fallman, 2011), Interviews (Wentz, Nydén and Krevers, 2012), or Group interviews (Brederode *et al.*, 2005). At some occasions, additional support is used to facilitate communication between researchers and children, for example by using Pictorial feedback (Nissinen *et al.*, 2012) or Talking Mats (Black *et al.*, 2012).

2.6 Social and emotional learning

This section will provide an overview of social and emotional learning, how it is taught to children in school, and give examples of how technology can be used as a support for social and emotional learning.

Social and emotional skills are crucial for everyday life and a healthy development (Slovák and Fitzpatrick, 2015). Most children acquire appropriate social skills quite easily, while others need to be explicitly taught them, e.g. children with autism who often have poor social perception, or those with severe disabilities who cannot form meaningful relationships (Mitchell, 2014).

In a review of existing approaches for teaching social and emotional competence, Slovák and Fitzpatrick (2015) have identified four sets of skills, see Figure 5, used to teach the core competencies shared by most existing curricula. Some set of skills are prerequisites for other, e.g. understanding your own emotions in order to manage them. Each set of skills consist of a set of complex and interrelated abilities which makes it impossible to teach them directly. Therefore, most curricula help learners progressively develop these competencies, i.e. to teach a complex skill curricula break the skill down into less complex subskills.

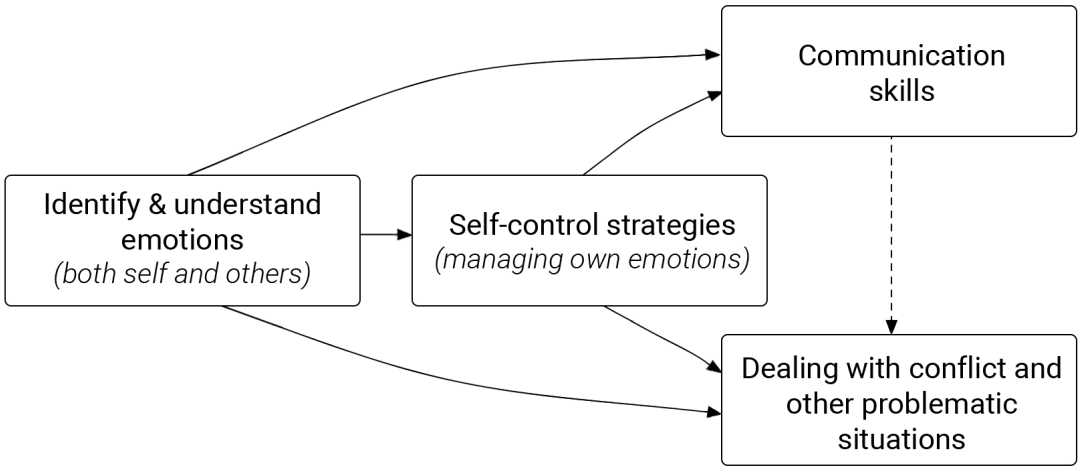

Figure 5: The set of skills identified by Slovák and Fitzpatrick (2015) and their dependencies.

The core of most curricula that teach social and emotional learning is a set of focused classroom lessons held once week throughout the school year (Slovák and Fitzpatrick, 2015). The most common techniques used during these classes include e.g. cooperative learning, modelling, posters, rehearsal and practice, role play, simulations, and video tapes. Once a skill is mastered in class a critical challenge is the transfer of the skill into everyday practice (Slovák and Fitzpatrick, 2015). Therefore social skills should preferably be taught in natural contexts (Mitchell, 2014). The transitions of skills from the classroom to outside contexts, consists of three underlying challenges; identifying moments in which to use skills, lack of scaffolding and support, and the need for reflection to learn from experiences. In addition, social support, from both peers, teachers and parents can be crucial for success (Slovák and Fitzpatrick, 2015).

2.6.1 Technology to support social and emotional learning

Incorporating technology in social and emotional skills learning can for some areas further improve it, or address some of the challenges faced by the curricula. Three examples of such areas are; the embedding of skills into everyday settings, helping to promote reflection, and providing mixed spaces for practicing skills (Slovák and Fitzpatrick, 2015). The embedding of skills into everyday settings can by supported by technology both by extending the learning support beyond the classroom, using mobile and sensor-based technology, and secondly by extending the network of support for learning social and emotional skills to for example parents. For reflective skills, technology can be used to increase emotional awareness, or to increase the awareness of one's body or breathing during e.g. relaxation. It could also be used to provide feedback during training in communication or interaction skills. Mixed spaces are for example games or virtual environments that combine the scaffolding available in classroom teaching, but with increased autonomy from the learner. Examples of social and emotional skills that can be trained in mixed spaces are self-control, promotion of perspective-taking, communication skills, and collaboration. Some related work, in which technology is used to augment social and emotional learning is presented below. Many of these utilize touch-technology that has made computing more accessible to a wide variety of populations, including children with autism (Hourcade *et al.*, 2013).

SIDES is a four-player cooperative table-top game for adolescents with Asperger syndrome (Piper *et al.*, 2006). The puzzle game is designed to increase collaboration and decrease competition. It aims to encourage meaningful application of group work skills such as negotiation, turn-taking, active listening, and perspective-taking. The touch-based technology used is able to distinguish between input from different players, who work together to build a path of different tiles to allow a frog to travel to a lily pad. The limited number of tiles encourage the players to build the most optimal path to win the most points by intersecting with insects of various value on the game board. In the evaluation of SIDES, the researchers also tested the game in different conditions; no-rules, human-enforced rules, e.g. a therapist or teacher present in the room, and computer-enforced rules. A majority of the players in the first of the two test groups preferred the computer-enforced rules and rated it as easiest to play, that they were the most relaxed and worked best in this condition.

The other group however stated the same for the no-rules condition. This group had challenges to work together in the enforced conditions, partially due to the inflexibility of one of the players who refused to give up his turn. Overall, the game was found to provide an engaging experience for the adolescents who usually find working in a group challenging.

ECHOES is a technology enhanced learning environment for typically developing children age 5-7 and children with high functioning autism or Asperger syndrome with an equivalent developmental age (Frauenberger, Good and Keay-Bright, 2011). The environment is manipulated by touch on a large vertically mounted display. ECHOES is designed to scaffold the development of social skills through a series of playful learning activities. The children interact with different virtual characters in different social situations taking place in a magical garden. The garden is filled with multi-modal interactive objects that can become the focus of joint attentions between one of the virtual characters and the child (Porayska-Pomsta *et al.*, 2011).

Hourcade, Bullock-Rest and Hansen (2012), developed a set of activities and touch-based applications together with children with autism, aged 5-14. The activities that were developed in relation to the different applications were collaborative storytelling and self-expression (drawing application), collaborative and individual music composition (music application), collaborative visual puzzle solving (puzzle game), and emotion modelling (image application). The study suggests that technology may be enough of an incentive to improve social interactions, possibly due to the more structured narrative in the interaction when children are focused interacting around the technology. It can also be important to allow children to interact with, and learn the skills required in the collaborative applications on their own, before trying them together. The paper also point out that designing activities in which technologies should be used, makes them more accessible for use at home or in school without the intervention of researchers (Hourcade, Bullock-Rest and Hansen, 2012).

In supporting children with autism, Malinverni *et al*. (2014) developed a motion-based game based aimed at fostering social initiation skills for children with autism. Hayes *et al*. (2010) developed different visual supports, i.e. Mocotos an augmented communicative support and vSked an interactive visual schedule. Similarly, the application MOSOCO (Escobedo *et al.*, 2012), based on a validated curriculum for learning social skills, uses augmented visual mobile support to allow children with autism to practice social skills in real-life situations.

Examples of applications developed for groups of children with mixed disabilities include e.g. Troll Forest (Zarin and Fallman, 2011), a suite of applications for a table-top system designed for children with special cognitive needs, and pOwerball (Brederode *et al.*, 2005), a mixed-reality cooperative flipper game for both typically developing children and children with physical and cognitive disabilities.

2.7 Summary

Developmentally diverse children are getting more and more involved in the design process of technology, but the level of involvement often varies, from just being observed to being involved in creative sessions. There are two main factors that can help the children take a more active part during the design process.

First of all, it is useful to involve the children in a familiar setting, with familiar adults helping to reduce e.g. anxiety and unwanted distractions. Adults who know the children can help in several ways during the design process. Initially they can introduce researchers to the children and help them to build a relationship. Later on, their knowledge about the children, for example their strengths, needs, interests, and motivations, can help both with planning a design activity and with carrying it out. During an activity, it is important with adult support, to for example help children carry out a certain task, or help them communicate in ways they are used to. After a design session, it can be important to discuss outcomes with a familiar adult.

Second, it is important to provide structure, both in individual activities and over several ones. During an activity, structure can be reinforced by informing the children about the activity both verbally and visually, and to provide e.g. a visual schedule of the tasks they will carry out within the activity. Over several reoccurring activities structure can be provided by scheduling activities during the same time and day each week, and by recapping the events and outcomes of the previous activities.

3 Process

This section presents the research and design process, including the participants in the project, as well as the activities carried out with the participants during the process.

3.1 Participants

3.1.1 School 1

School 1 is a compulsory school for children with learning disabilities (Skolverket, 2014b) in the second largest city in Sweden, Gothenburg. This school has been involved in the whole project, from fieldwork to design workshops.

Children
Children from two classes in this school have been involved throughout the research project, see Figure 6.

The first year

Younger class ***10-12 years old***
Hanna
Benjamin
Anna
Olivia
Robin
Theo
Marcus

Older class ***13-16 years***
Nicholas
William
Adam
Linda
Samir
Isabella

Teachers
Frederic
Pamela
Nathalie

Special needs pedagogue
Sandra

Other staff
6 Assistants

The second year

Merged class		
Younger	***Middle***	***Older***
Hanna	Robin	Adam
Benjamin	Theo	Linda
Olivia	Marcus	Samir
Anna	William	Isabella

Teachers
Nathalie
Joseph

Special needs pedagogue
Sandra

Other staff
6 Assistants

Figure 6: Participants from school 1.

Teachers
During the first year of the project three teachers, a special needs pedagogue, and six assistants were involved. At the end of the first year, two of the teachers quit their jobs. During the second year of the project the two classes were combined into one. However, as the class became quite large, the children were often split into three smaller groups, as can be seen in Figure 6.

Parents
Parents to children in this school took did not take active part in the project. However, they have been informed about the project during two parental meetings as well as through information sent out together with the informed consent.

3.1.2 School 2

School 2 is a compulsory school for children with learning disabilities (Skolverket, 2014b), located in a smaller municipality about 60 km from Gothenburg, with about 70 000 residents in the main town. This school has been involved through fieldwork during the first year as well as in focus groups held for teachers during the second year.

Children
In this school children from one school class took part, as well as a group of children from different classes during the lecture *'pupil's choice'*. All children were between 13-16 years old.

Teachers
During the first semester, an IT teacher, and an assistant were involved and fieldwork was done during the IT lecture that was held bi-weekly with a school class. Due to organizational change this IT teacher became assistant principal, and fieldwork was put on hold. During the second semester, the IT teacher held the lecture *'pupil's choice'* in which children from different classes built Minecraft structures from blueprints. In addition, one of the regular class teachers became more involved in the project. During the second year, four class teachers took part in two focus groups for teachers.

Parents
No parents in this school took active part in the project, but were informed about the project through information sent out together with the informed consent.

3.1.3 Other schools

Two other compulsory schools for children with learning disabilities (Skolverket, 2014b) in Gothenburg, were involved in the project. However, the researcher did not work directly with these children, teachers and parents. Some of the children in these schools followed the curriculum for training school (Skolverket, 2014b).

3.1.4 Activity centre for adults

During the first year, an activity centre for adults was involved in the project. The idea was to engage in fieldwork at the activity centre to better understand adults with intellectual disabilities. It was also discussed whether the activity centre could be involved in design activities during later stages of the design process, but so far no such activity has taken place.

3.1.5 Ethics

All participants described in this thesis have received fictitious names to hide their identity. Teachers, parents and children have been informed about the aim of the project and the research focus. Parents have signed a written informed consent before each semester, reminding them of the ongoing project. For some parents, the consent was given over phone with the child's teacher. Children have been given a choice whether or not to take part, and could leave at any time during design activities.

3.2 Research and design activities

The research described in this thesis falls under the tradition of research through design and is closely intertwined with a human-centred design process in which the children are involved in design activities. As research in the field began at the outset, the fieldwork is quite explorative in finding its scope, which perhaps sets it apart from other research and design projects involving developmentally diverse children. While no specific overarching approach or method has been used verbatim to include the children in different activities, important findings relating to the importance of familiarity, structure and adult support presented in the background section of this thesis have been guiding in the creation of the different activities. Additionally, the teachers have played an important role in forming these.

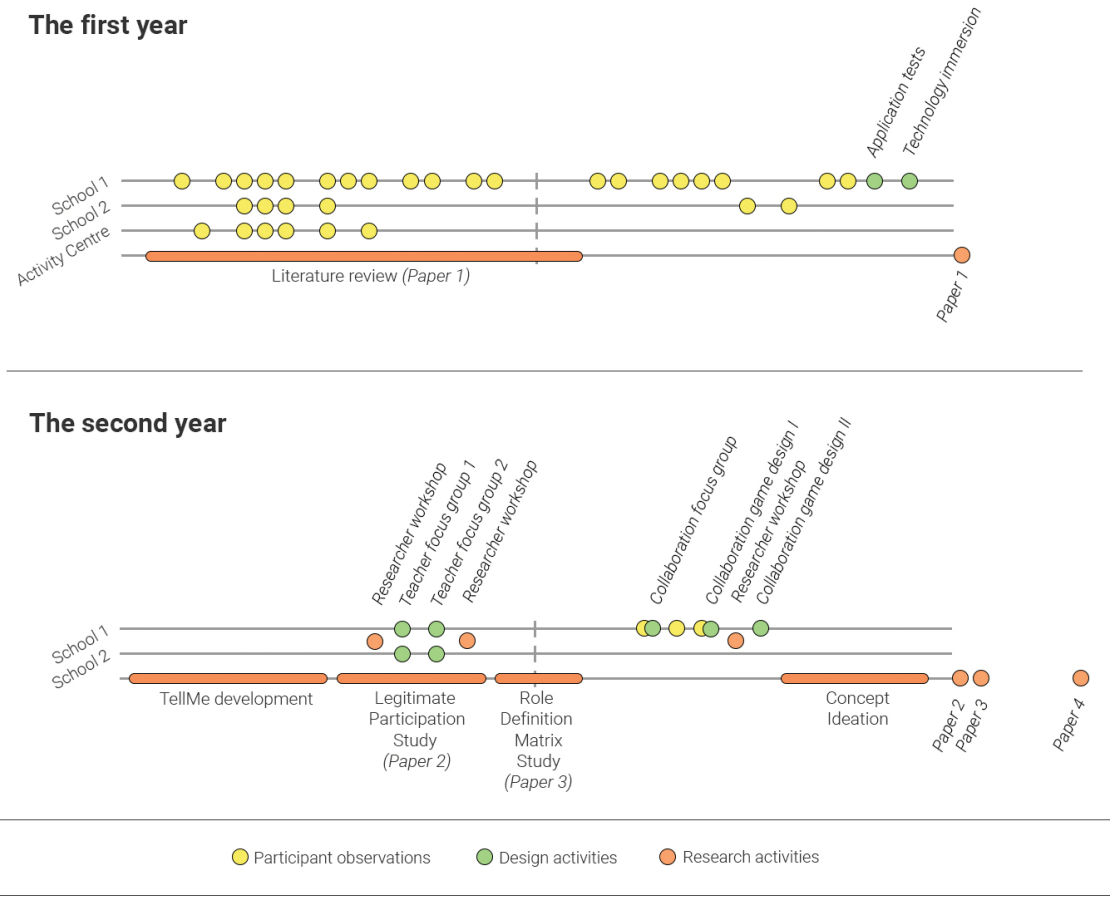

Figure 7: The different activities conducted during the design and research process.

For two years, research- and design activities have been conducted at the two schools and the daily activity centre, see Figure 7. The activities are described in more detail below, e.g. how they were carried out, what was learnt from them, and outcomes for the design. In addition, several workshops and meetings have taken place between the involved researchers. Some of these, in which potential concepts have been found or key decisions have been made are also described briefly within the process and can also be seen in Figure 7. The produced research papers and design concepts will also be indicated in this figure to give an understanding, not only of the design process, but the research process as a whole.

3.2.1 Fieldwork

Fieldwork has been conducted throughout the research and design process. At the outset, the fieldwork had three purposes. First, to get to know the context of Swedish special education and the target group, developmentally diverse children. Second, to find a focus and design opportunities within the quite wide scope of social and emotional development. Third, to build a relationship with the children and teachers in the school, as recommended by e.g. Piper *et al*. (2006), Keay-Bright (2012), and Holone and Herstad (2013).

During the first year, two classes from school 1 (see Figure 6), were visited weekly. The class of younger children during the fall and the older class during the spring. In the second year, fieldwork was often done in relation to conducting other design activities together with the children. The fieldwork conducted in school 1 is described in more detail in Paper 4. As a summary, in this school, the teachers allowed the researcher to take active part in the school activities, and gradually the role of the researcher and the teacher started to align. This allowed the researcher to engage more deeply with the children in different activities and to come closer to their practices. It also meant that several school activities were adapted to fit in the with the current research focus, e.g. discussing certain topics during class, or designing and programming a game in Scratch collaboratively. The regular visits that took place over a long period of time, also made it easier to build a relationship with the children and teachers. These relationships have been of great help in planning and conducting the design workshops described below.

School 2 was only visited on a total of six occasions. The fieldwork in this school was significantly different from the fieldwork in the other school, as the researcher could not take active part in the activities. During class, the researcher was asked to sit at the back of the classroom, and did not take part in any breaks or lunches.

During fieldwork at the daily activity centre, the researcher took take part of different creative activities, e.g. recording songs, building a TV-studio, recording stop motion films or music-videos, together with the individuals that worked there.

3.2.2 Design workshops

The design workshops described below, were all carried out with children and teachers in school 1 during the first year of the project.

Application tests

In this first design workshop, children from the older and younger class tested different existing applications and ways of interacting around them. The format of the workshop was planned together with the class teacher Frederic, and had similarities with the method visits and demos (Hourcade, Bullock-Rest and Hansen, 2012). Four applications were chosen, related to social and emotional development, see Figure 8. Two of them had a stated educational goal of helping children learn about emotions, while the other two applications were not educational but had elements of collaboration in them.

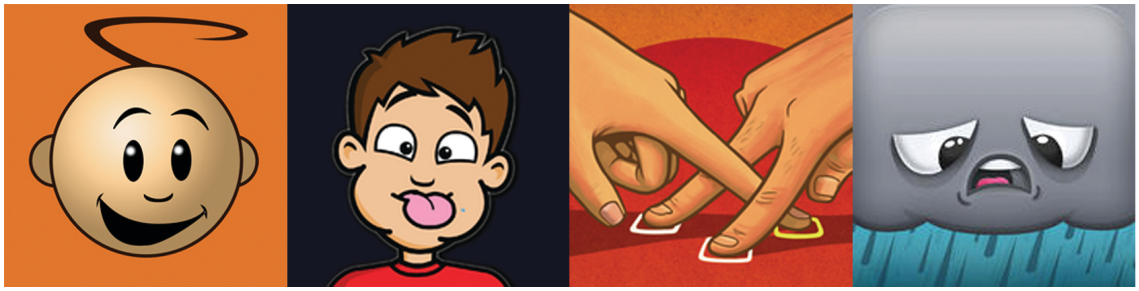

Figure 8: Applications tested during the activity, Empatico, Smarty Pants, Fingle, and Nimbus.

The children tested these applications in pairs and were free to use them in any order they wanted and for as long as they wished, but they were instructed to try all of the applications at least once during the workshop. After the session, a group discussion was held about what was good about each application, and what could be better. The discussion focused on likes and dislikes about the different applications, in line with for example Sticky Noting (Guha, Druin and Fails, 2013).

From this workshop, it was noticeable that the children enjoyed collaborating around games. For some children, this really surprised their teacher, e.g. the boy Marcus from the younger class, who was often reluctant to collaborate with anyone, really enjoyed the games that focused on collaboration. The children expressed that they enjoyed it when the games in the test got increasingly difficult, but as the games got too hard, the researcher or their teacher was often invited to help them through the complex parts.

One of the games in the test featured a possibility to skip levels, a feature the children had mixed feelings about. Some thought it was good to be able to skip a level that was too hard, while others said that there was a risk that you would only try a level once, and if unsuccessful, skip it immediately. This could then affect how well you would perform on the next level, and so on. In one of the other games it was possible for a skilled player to play alone, something that was pointed out as problematic.

The older children enjoyed the free format during the testing and being allowed to switch between applications, and were engaged in the group discussion. The younger children however, would have benefited from more structure during the testing. A format where they tested each game one at a time and then provided feedback on that game individually before testing the next game would probably have been better. During the group discussion, some of the children lost focus.

Technology immersion

The technology immersion workshop acted both as a way of exploring technology together with the children (Druin, 1999), and as a way to thank them for taking part in our project for a full year. The children were invited to our design studio where they could interact with different technologies, e.g. Lego Mindstorms, a 3D-printer, a Microsoft Surface Table, and a Telepresence robot, see Figure 9.

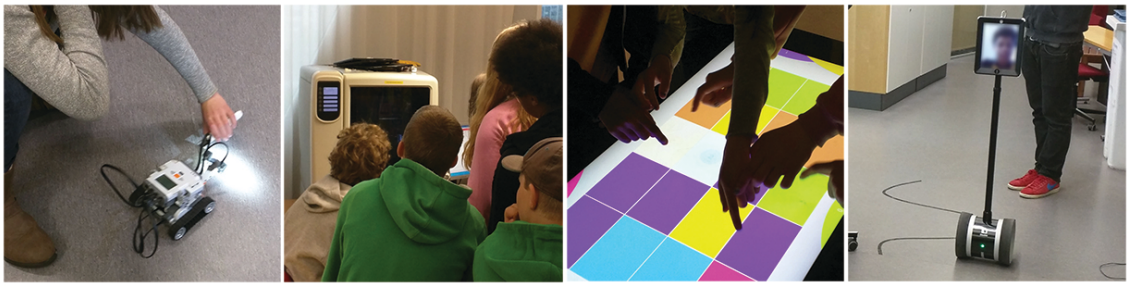

Figure 9: Activities during the Technology immersion.

While both younger and older children were invited to take part in this workshop, the teacher decided that only the older children should come. As in the first workshop, the children could choose what they found the most engaging to interact with, and could move freely between the different technologies, once they had been introduced.

During this workshop, it was once again observed that the children enjoyed collaborating around technology. The children collectively tested most of the available applications on the Microsoft Surface Table. However, it was also observed that while the collaborative experience around the technology engaged them, children at times got disengaged and left the group to explore some other technology. After a while they often got drawn back to the group and reengaged in the experience.

The free format of the workshop once again gave answers about what technology the children enjoyed interacting with, but also in what way, e.g. as a group, on their own, etc. For the children, it was also seen as a reward and the children often asked when they could come back to the studio to try all the cool stuff again.

Researcher workshop
In this workshop, the researchers analysed the field notes from the first year, based on observations and informal interviews with teachers, and assistants as well as the outcomes of the first two design activities with the children. Affinity diagrams were created related to e.g. different social and emotional skills that could be addressed by technology, requirements for methods or technology involving developmentally children, as well as ideas for concepts. Through the analysed material, the area of collaboration emerged as promising to explore further, with many observed examples both of how children enjoy, but also struggle with different forms of collaboration. This workshop formed the basis for the two workshops with teachers described below.

3.2.3 Focus groups

The focus groups with teachers were conducted in both school 1 and school 2. The focus group with children was done in school 1. The focus groups were held during the second year of the project.

Teacher focus group on current practices
The first focus group held with teachers explored current practices concerning social and emotional learning in school. The discussions concerned which social and emotional skills they considered most challenging for the children in their classes, how these difficulties manifest themselves, but also how the teachers work with developing social and emotional skills. In this focus group teachers were involved as experts (Börjesson *et al.*, 2015). To support the discussion, around 60 different social and emotional skills were printed on sheets of paper, and teachers also brought in artefacts, e.g. books, and work sheets to describe how they worked with the children. The researcher could also use the experience from the fieldwork to bring up different examples of situations that could both feed the discussion, or needed clarification in light of the things brought up.

During both focus groups, many social and emotional skill were discussed. According to the teachers, the ones that children seemed to struggle with most were theory of mind, or understanding how others think and feel, understanding their own emotions, collaboration and understanding their being part of a whole, managing a conversation, dealing with failure, and persisting even when something is hard.

Teachers from both schools explained that they worked with these difficulties both during class e.g. discussing emotions, or practising collaboration, and 'in-the-moment' when something happened. They often referred back to previous events to support the transfer of skills from a classroom setting to these real world situations (Slovák and Fitzpatrick, 2015). This could for example both be to refer back to a class discussion during a conflict between two children at lunch, or to give general examples of behaviour or incidents that had occurred at school. Teachers explained that when giving examples it could be better to show correct behaviour rather than showing examples of bad behaviour and asking what was wrong about it. They felt it was important to reinforce good behaviour and to encourage the children in what they are good at.

Teacher focus group on new perspectives

This workshop built further upon the results from the first focus group e.g. the most difficult social and emotional skills for the children to manage, and the ways teachers worked with teaching them, and introduced a number of new perspectives about technology, interaction, people, context, and input-output (see Figure 10). In this focus group the teachers were involved as experts, but also as users and proxies (Börjesson *et al.*, 2015) as they reflected on the new perspectives, like technology in the classroom, not only from the perspective of all children, but in relation to individual children and themselves.

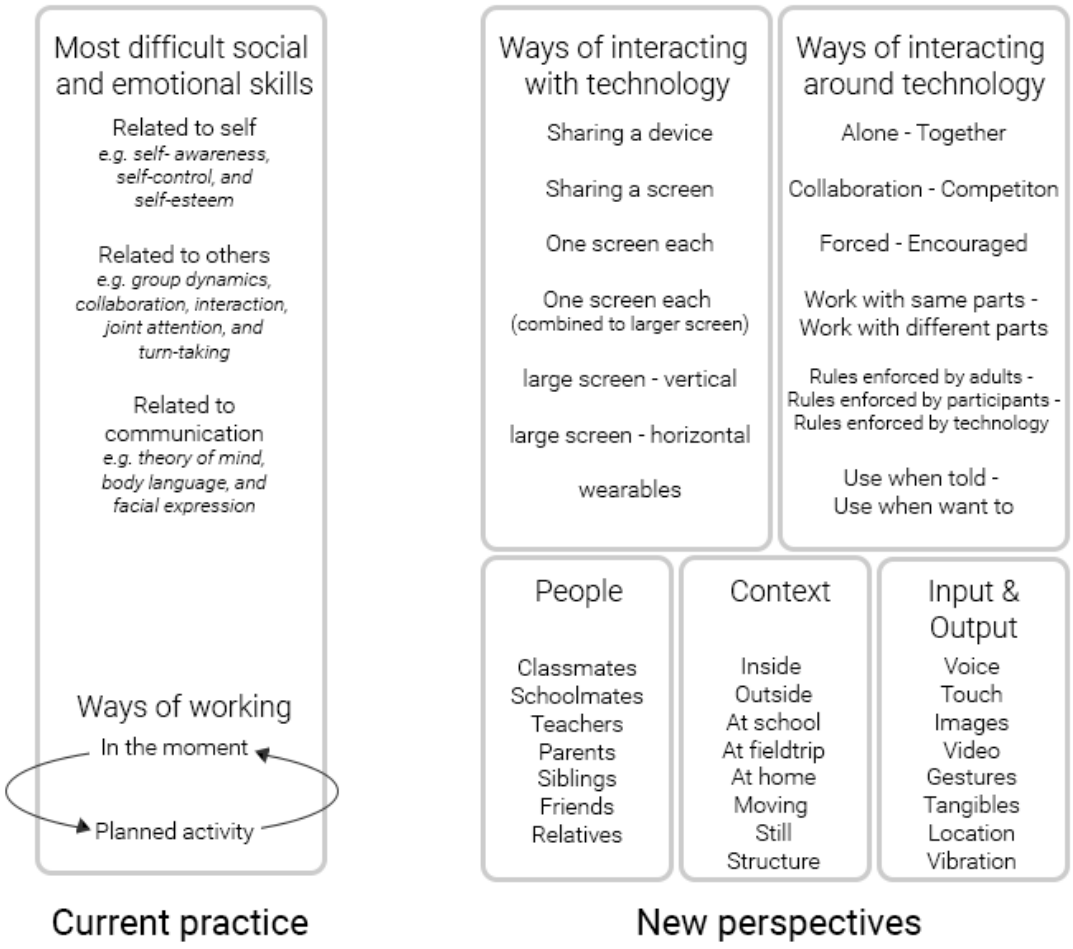

Figure 10: Current practices and new perspectives discussed during the second focus group with teachers.

Both current practices and the new perspectives were designed as cards that could be arranged to form different scenarios, e.g. train collaboration, together with a classmate, sharing a device. With cards, different aspects could easily be changed and the implications of that change discussed. Desired outcomes from the focus group were both to get concrete concepts to work further with and to learn for example “it will never work, having four children share a tablet” or “It would be great if the children could work with these things at home together with their family”.

In summary, the teachers seemed to consider technology both as a curse and a blessing. One teacher said that for the children, using technology could be a reward in itself, while another pointed out that some children could interpret a problem presented through technology as having only one solution. Using technologies could sometimes counteract its own purpose, e.g. when children got stuck on a rewards screen with fireworks, or focused solely on getting a max score rather than the learning process. One of the teachers said that she rarely used tablets during class anymore, as finding good applications for them felt like finding a needle in a haystack. In one of the schools the children were allowed to bring their tablets home, while in the other they only used them in school.

According to the teachers, the children usually worked on their own when using technology in school, most often on their tablet. When sharing a device, or screen, they felt it was common that one of the children took over, while the other one became passive. Taking turns could also disengage children. Technical solutions where all children can stay engaged when working together were seen as the most promising, e.g. a tablet functions as an access point to a shared virtual space, or several tablets are combined into a larger screen. The teachers advised against competition, as this could often be problematic, and for example cause stress. They also perceived a risk with competition in teams as one child could end up being the scapegoat. Although the teachers admitted that some children enjoy competition they often thought it was better if they competed against themselves. They also pointed out that it is good of children can practice collaboration in pairs before doing it in larger groups.

All teachers preferred rules enforced by technology, for various reasons. They felt that when rules were enforced by participants it often ended in conflict. In one of the schools, they had enforced school rules to the Uno card game as children all had different family rules of the game. Some teachers argued that technology enforced rules had the benefit of being accepted without being questioned. It was also pointed out that corrections from technology were often less intimidating than from teachers, e.g. red marks in word processor compared to red marks from a teacher. One of the teachers stated that if teachers were needed to enforce rules when the children are using technology, then there was no point in using technology at all.

Technology as a bridge between school and home was also discussed and seen as promising. However, it was pointed out that this depended a lot on the parents' experience of technology. In the school were children were not allowed to bring their tablets home it was also pointed out that not all families have tablets or computers at home.

Researcher workshop

After the focus group with teachers, different options for collaborative applications were discussed, e.g. storytelling, games, or applications in which children could cooperate doing school work or collaboratively discuss certain topics. None of

these were crossed out[2], but at the time it was decided to start exploring collaborative games together with schools. To proceed, a focus group were held with the children on the topic of collaboration (described next), followed up by two workshops in which the children designed collaborative games (described below). Two bachelor's thesis student groups were also involved in the project to design collaborative games for developmentally diverse children.

Children focus group on collaboration

The aim for this activity was to elicit the children's understanding of collaboration, how they explained it, what examples they gave of it, and whether or not they liked to collaborate with others. While developmentally diverse children are usually not involved in focus groups (Börjesson *et al.*, 2015), it was observed during fieldwork that the children were used to the format of discussing different topics as a group. The initial idea was to hold the focus group with the whole class, but the teacher advised that it would be easier for the younger children to take active part if the class was split into an older and a younger group. These groups were facilitated by their class teachers based on topics for discussion that were provided for them by the researcher, e.g. what is collaboration, with whom do you collaborate, how do you collaborate, why do you collaborate, when and where do you collaborate?

The children were able to give many examples of collaboration, e.g. group work in school, cooking, taking care of a horse, playing football, playing musical instruments together, doing homework with parents etc. They said that one can get better at collaboration by practicing it, that it is often fun to collaborate and that you can learn from each other. When collaborating, they preferred doing it with a friend. However, some children stated that they preferred to work alone. The children also acknowledged that there is a risk of conflict if you do not listen to others while collaborating, and possibly that someone may take over and decide everything.

During the focus group, some children seemed to be bored and got distracted, a behaviour that had also been observed at times during fieldwork. Similarly, children who were often quiet and rarely took active part in discussions during class, behaved similarly during the focus group. One difference to other focus groups conducted with developmentally diverse children e.g. (Nazneen *et al.*, 2010; Garcia *et al.*, 2013) is that the teachers were involved as facilitators (Börjesson *et al.*, 2015). Therefore, the two groups were facilitated quite differently. The teacher in the younger group led the discussion based on what the children said and often reconnected to things that had been brought up previously, while the teacher in the older group had the strategy to suggest different examples that the children responded to. Both teachers used their knowledge about their practice and the children to try and engage inactive children. In the younger group the teacher often had to correct unwanted behaviour, e.g. children saying mean things to each other. During the focus groups, the researcher was walking between the two groups but as the older group did not want to be recorded, more time was spent in this room.

[2] In fact, some of them have been explored in workshops not described in this thesis.

3.2.4 Game design workshops

The game design workshops described below, were all carried out with children and teachers in school 1 during the second year of the project.

Collaboration game design I

In this workshop, the children got to design a game. While not directly resembling another method, it was heavily influenced by the approaches described in IDEAS (Benton *et al.*, 2012), and Scenario Design (Millen, Cobb and Patel, 2011), e.g. involving teachers, and providing familiarity and structure. The class teacher was involved in the planning of the workshop, and teachers and assistants acted as facilitators (Börjesson *et al.*, 2015) during the workshop.

For this workshop, a few different ideas for an activity were discussed with the class teacher Nathalie, e.g. to redesign an application that the children liked so it could be used collaboratively by more than one child, or to redesign an object such as a car or a camera to be used by more than one person. Nathalie however, preferred the third idea where the children should design a collaborative game or application. The workshop was planned to be done in pairs mirroring the groups they were usually divided into and to last for about an hour, including introduction, ideation, and presentations. However, as some children and regular assistants were ill that day, the groups had to be reorganized into three groups of 3-4 children, corresponding to the younger, middle, and older group shown in Figure 6. There were also changes in their regular school activities, i.e. shorter morning assembly and no story time, as Nathalie had to inform the substitute assistants covering for the sick assistants.

The workshop started with an introduction for the class, which outlined the structure of the activity, and the three requirements of the game; it should be played by two players with a tablet each, they should be seated at the same table, and they should collaborate in the game. It was also explained to both children, teachers and assistants that the most important thing in this workshop was to capture the children's ideas, and that no consideration had to be given to whether an idea was hard to or even impossible to implement. After this the three groups were seated in different rooms in order not to disturb each other, assisted by two adults from school staff. As the researcher could not be in all rooms at the same time, all sessions were recorded.

The three groups were handed a design kit, which included the description and instruction that had been given verbally, one for the children and one for the teacher or assistant that facilitated the activity with the group. The kit for children included a visual and textual support about the requirements of the game, to be used during the workshop. The children were also given templates of a tablet, on which they could draw and show their design ideas. The kit for the teacher or assistant explained the requirements in more detail, and reiterated that the main purpose behind the workshop was to elicit the children's ideas and reasoning about collaboration, and what they found fun and engaging.

The outcomes in the different groups varied. In the younger group, facilitated by the class teacher Joseph, and a substitute assistant, the ideation was heavily influenced by Joseph who came up with most of the ideas and mainly asked the children to give feedback on them. In addition, the children barely drew anything. While some of the children in this group are less communicative and need more prompting and guidance it was clear after reviewing the audio recordings that Joseph had a vision for the game. One of the reasons that the children did not draw anything was based on Joseph's assumption that the children had to draw very small in order for a game character to fit within in the template, and therefore suggested to the children that he should draw instead. The game concept from this group was a maze game (see Figure 11) in which one could play as either a princess or Lionel Messi, a famous football player, and save the other character. The two characters had different super powers. After one of the players had saved the other, they both worked together to find the exit.

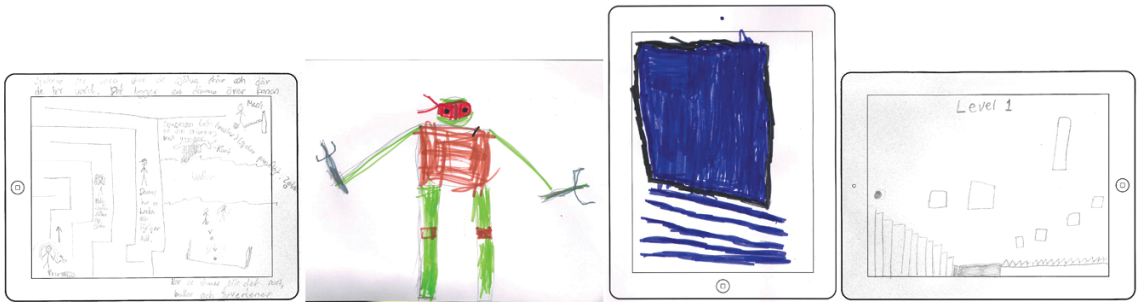

Figure 11: Game concepts from the children. A maze game from the younger group, a ninja turtle and a portal from the middle group, and a geometry game from the older group.

In the older group, facilitated by an assistant, the problem was getting the children to collaborate during the workshop. Adam, quite early on disengaged from the group by first stating that he did not have any ideas, and later on by refusing to move forward with Linda's and Isabella's ideas. At first the two girls and the assistant tried to engage him, both in their own ideas and by asking him about his ideas. The girls were interested in making a game about a horse, while Adam wanted to make a game resembling air hockey. In the end, guided by the assistant they came up with another idea for a game, that was heavily influenced by an existing game. After this the focus on collaboration was lost and the children focused on designing the different levels of the game. The game concept was a geometry game (see Figure 11) where players helped a rolling ball get past different obstacles shaped as different geometric forms.

The middle group was facilitated by the class teacher Natalie and an assistant. While the children in the second group struggled with their creativity the children in this group had a lot of ideas. However, they struggled with combining individual ideas into a common game, as one of the children was currently obsessed with Ninja Turtles, and another with Shrek the ogre. The third had no strong preference for the theme of the game. Nathalie guided the children in combining the two conflicting ideas into one. After this a number of game elements that needed to be drawn and described was decided and the children were allowed to work on them. This approach worked very well and provided structure for the children, even if it was still

a bit unclear how collaboration in the game was to be carried out. The game concept was a game with two worlds, one for Shrek the Ogre and one for the Ninja Turtles (see Figure 11). At certain times one of them would get in trouble and be in need from the other who would come over to the other world using a portal.

After the ideation, the children got to present their ideas to the class. This gave the researcher, their peers, and their teachers, a chance to hear their ideas again, and to give them praise, feedback, and ask them questions. Although most children were able to present their work, and listen to each other, one of the children was acting out, booing at the others and showing them a thumb down, and the teachers and assistants had to correct him several times.

Researcher workshop

In this workshop, the researchers synthesized the findings from the game design workshop, both concerning the game concepts, and the method for involving the children. While some concepts seemed more promising than others, it was decided to continue to explore them all further, to show children that their ideas were valued. The three concepts were refined and adapted for four tablets, and for each concept a number of questions were defined, related to the collaborative mechanisms in the games, e.g. how to interact and collaborate with the other players, through different game objects.

Collaboration game design II

This workshop was designed by the researcher to provide more structure for the children during the design activity. Each game concept was low-fidelity prototyped and brought back to the school, to help explain the concept of each game to the children (see Figure 12). Each concept was based on the children's ideas from the first workshop, e.g. a labyrinth game, a portal game with different worlds, and a geometry game. For each game, a number of questions were presented for the children to answer and design solutions to. These were mostly related to the collaborative aspects of the game, for example; why do game characters need to go through the portals to another world (tablet), or what happens when a game character goes through a portal to another world (tablet), who controls that character?

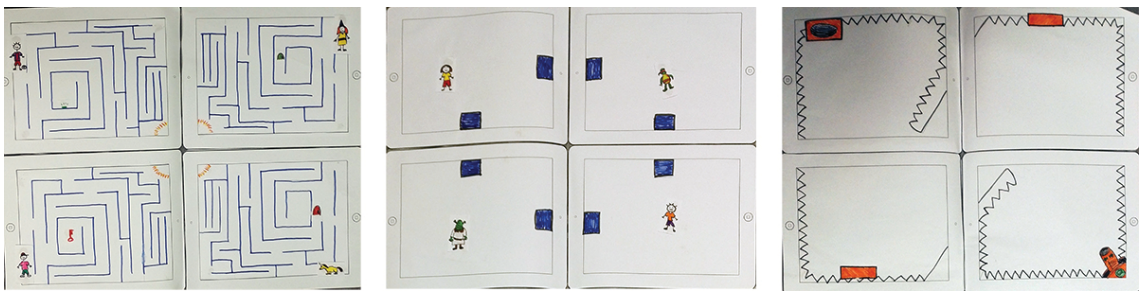

Figure 12: The refined game concepts for the second collaborative game workshop.

As in the first workshop, there were also design kits prepared for the children and teachers. The kit for teachers once again focused on explaining the main purpose of the workshop, as well as a short description of the concepts and the related questions. The kit for children included a large sheet of paper on which four tablets created a common game area (see Figure 13). Additionally, the children were given a template to describe design ideas in text and drawing, in order to make their ideas more transparent.

Figure 13: Part of the material in the design kit for children.

The initial idea was to introduce the refined games concepts to the children and allow them to choose which one they wanted to continue to work on, and by that get an indication on which concepts the children found the most engaging. This was however something that their teacher advised against, as this could cause too much unrest among the children. As a result, some children were unmotivated to take part in the design activity as they expressed that they would have preferred to work with one of the other concepts.

These issues were most apparent in the older group, were Adam decided to instead produce ideas for the labyrinth game on his own. Collaborative work in this group was further affected by the fact that Isabella was sick, which had the effect that Linda did not really take part in the activity. The only one engaged in developing the geometry game concept further was Samir, that had been sick on the first occasion. The younger group was again facilitated by Joseph and relied a lot on suggestions and ideas from him to produce ideas. This time however, the children could contribute more directly by drawing and explaining different game objects using the templates to describe design ideas. The middle group, once again facilitated by Nathalie was the one that was most focused on the collaborative elements of the game, but also decided on two additional worlds to add to the game as it was adapted from two to four tablets.

The idea of bringing refined concepts back did not work as well as expected. As stated above, the initial idea was to have the children choose a concept that engaged them. However, as the teacher advised against that, the children ended up working on the same game, and some children were less motivated by this.

Overall, children were more engaged in creating a theme for a game or deciding who the game hero should be. In this workshop, questions around collaborative mechanism were asked in relation to game objects, e.g. why do players need to go through a portal, or what kind of items could be found that you could use to help the other players. This seems to have elicited some more responses related to the collaborative aspects of the concepts. For example, the children suggested that players should have different powers in order to help each other, and that players should do something on their own tablet, to help other players on their tablet.

3.3 Designs and concepts

As described under 2.6 Social and emotional learning there social and emotional skills are often taught in four sets of skills: identify and understand your own and others emotions, self-control strategies, communication skills, and dealing with conflict and other problematic situations. This section will give an overview of different designs and concepts that work with various aspects of social and emotional learning connected to self-awareness, communication, and collaboration. All concepts are developed to utilize technology that already exists in school, or that can be acquired for a low cost.

The overview starts by describing TellMe, which is now released and available for special education schools in Sweden. In the TellMe Diary application children can practice reflection and self-reporting while creating diary entries about their day in school that are then sent to their parents. At home, the parents can use the TellMe Contact Book to engage the children in a conversation focused around this diary entry, allowing children to communicate and elaborate on the day in school with the diary entries as visual support.

Next, the overview describes two designs, CirkVa and MindVenture that have been designed and developed as part of bachelor projects connected to the project. Lastly it describes two design concepts, StringForce and Pearls ‘n’ Pirates that are not yet evaluated with children. CirkVa, StringForce and Pearls ‘n’ Pirates are focused on getting the children to collaborate around and through technology and on breaking the mobile bubble, i.e. to use mobile technology for co-located interaction with others.

Additionally, the project has developed a touch-based application that can be used by developmentally diverse children for self-reporting e.g. psychological health (Boström and Eriksson, 2015) helping children identify and understand their own emotions. This application will however not be described here since I have not been directly or indirectly involved in its design, development, or evaluation.

3.3.1 TellMe

TellMe consists of two applications, TellMe Diary and TellMe Contact Book. The applications are used to support communication between children, parents and teachers in special education. The first version of the application was developed as part of a master thesis with School 1 (Fohlin, 2014), but was not stable and secure enough to keep using. As the Touch-AT! project started up, it became clear that the application had been very popular, and was missed. Therefor it was decided to build a new version that could be used not only by the school, but be released and available for any school.

TellMe Diary

The TellMe Diary is a tablet application used by the children in school to create a diary entry with images and text, describing something from their day in school (see Figure 14). Diary entries can be created as the event occurs, or at the end of the day to support reflection, e.g. to make a diary entry about the best part of the day in school. The diary entry is then sent to the child's parent and can be used as support in talking about the child's day in school. The application can also be used to browse through all the diary entries.

Figure 14: Diary entries in the TellMe Diary application.

TellMe Contact Book

The TellMe Contact Book application is used by parents and teachers (see Figure 15). As described above, this application can be used to view the child's diary entries. In addition, the application can be used for communication via text messages, between teachers and parents. The idea is to support the child's transition from home to school, and vice versa, allowing parents or teachers to quickly be informed about the child's mood or any special event.

Figure 15: Conversation between a parent and teacher in TellMe Contact Book application.

3.3.2 CirkVa

CirkVa is a collaboration game developed as part of a bachelor thesis, in the Touch-AT! project (Alvmo *et al.*, 2016). In this game, two or four tablets are connected to form a game board on which players need to solve a puzzle collaboratively (see Figure 16). The players control the movement on one tablet each, and the idea is to get each circle to the square of the same colour. There are obstacles in the form of walls, that can be removed temporarily by putting any circle in the square with the same colour as the wall. It is also possible to move circles between tablets, by using the portal, shown as two triangles on one tablet each. These triangles also show how to arrange the tablets when they are combined into a game board.

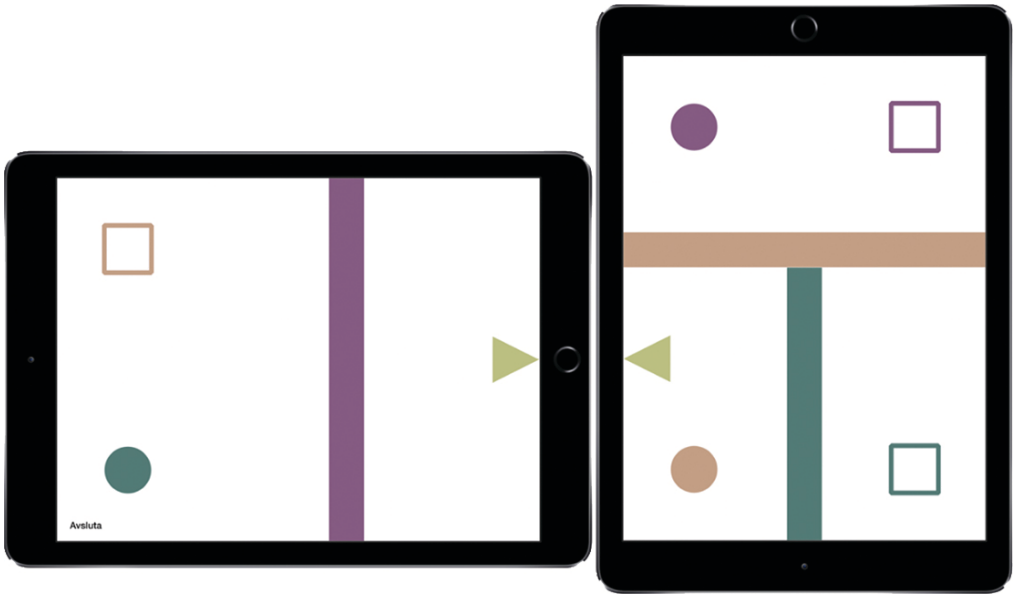

Figure 16: Two tablets arranged to form a game board in the puzzle game CirkVa.

3.3.3 MindVenture

MindVenture is a brain controlled collaboration game for two players, developed as part of a bachelor thesis in the Touch AT! project (Johanneson *et al.*, 2016). To interact with game, players use a headset that can measure either focus or relaxation.

Collaboration mechanisms

In the game, players control the thrust of two rocket engines with the intensity of their focus or relaxation (see Figure 17). One player controls the forward thrust, while the other player controls the upward thrust. Additionally, the game is designed to ask players to make a mutual decision about the path to take at certain points.

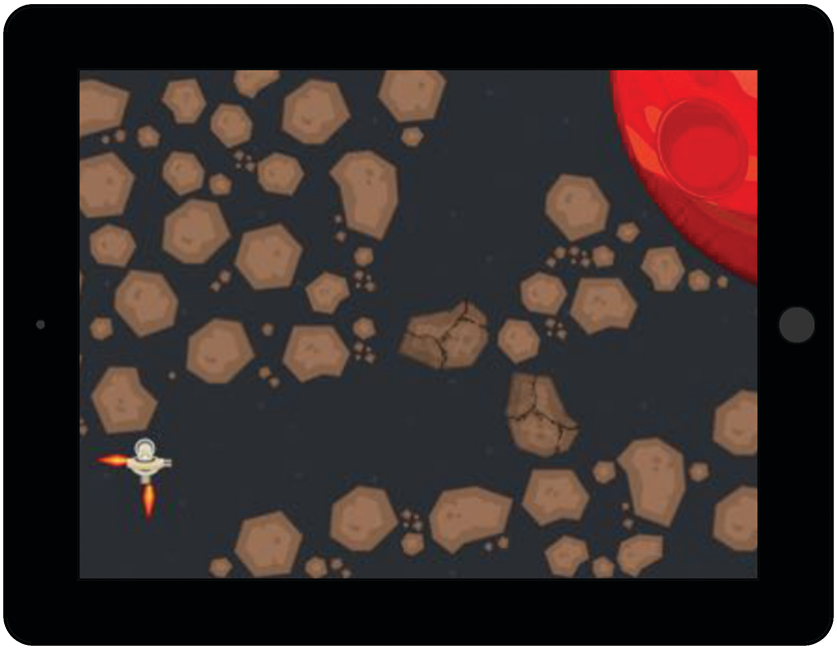

Figure 17: The MindVenture game.

3.3.4 StringForce

In StringForce, four players collaborate in moving a cursor connected to four strings to collect items on a large game board, created by arranging four tablets next to each other (see Figure 18). There are also obstacles to avoid. When players progress through the game, both collectable items and obstacles move around to make the game more difficult.

Collaboration mechanisms

To beat a level, the players will need to collect all items with the cursor and avoid the obstacles. The cursor is moved simultaneously by all players by either retracting or releasing your part of the string. The game requires the players to both create a common goal, i.e. the item to collect next, and constant communication about how to reach that item.

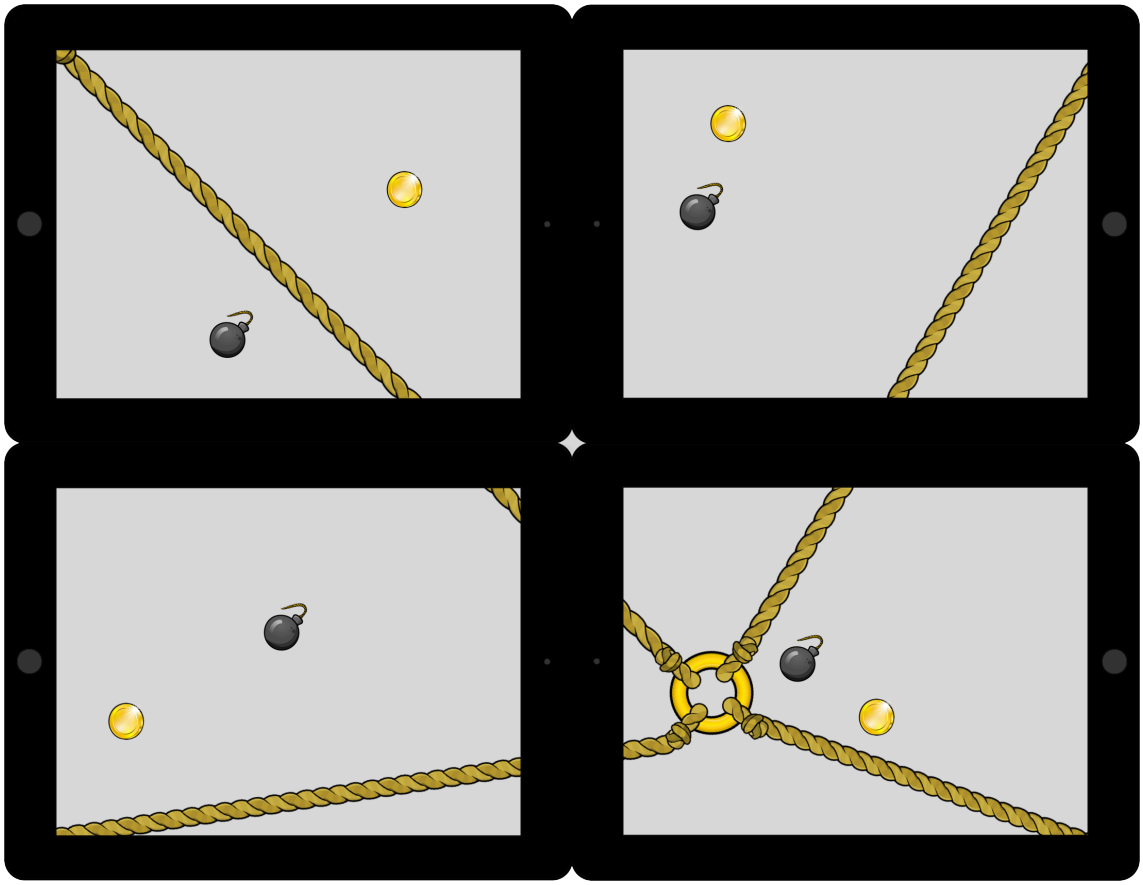

Figure 18: Four tablets arranged to create a large game board in StringForce.

3.3.5 Pearls ‘n’ Pirates

Pearls ‘n’ Pirates is a collaboration game in which four players work together to defeat the pirates. As in StringForce, four tablets are arranged to form a game board consisting of a large ocean with a pirate island in the middle. On each tablet, there is a player island with powerful pearls that can be used to help the other players. The game elements consist of player ships, pirate ships, treasures, as well as non-player characters and obstacles e.g. sharks, octopuses, oil, barrels, and rocks, see Figure 19. Each turn the players can move their ships collaboratively use the pearls to help each other.

Collaboration mechanisms

In order to win, the players need to either destroy all pirate ships, or collect all treasures, and at the same time make sure that no player loses their ship. If a player ship is destroyed, the game is lost. To be able reach any win condition and keep the players ship afloat, the players need utilize the power of the pearls. Each turn they have to decide how to distribute these limited powers; each pearl, *fire*, *nature*, and *light* can only be used once per turn, and the effect can vary depending on the element it is used on, e.g. *nature* on a player ship heals it, while an octopus will be frozen, *fire* on a pirate ship damages it, while an unfrozen octopus will dodge it. To use a pearl, three of the players touch and hold the pearl on their tablet while the player receiving the power drags it to the game element they want to use the power on.

Figure 19: Game elements in the game Pearls 'n' Pirates

Seamless connection

During tests of the game CirkVa it was notes the children struggled with the necessary steps to setup the game. The children had difficulties both with the order of actions, and became competitive about being the one hosting the game. Therefore, a challenge in the design for the both Pearls ‘n’ Pirates and StringForce was to design an improved way to handle the connection and setup of the game. As the children became competitive about being the one that hosted the game, the connection was designed to conceal which tablet that hosted the game and removed the action of inviting others to the game. In the new version, children simply chose a team to play in together, see Figure 20.

The next part of the challenge was to arrange the tablets in the correct way to build the game board. This was solved by asking the children to puzzle together an image showing the team they have chosen to play in, see Figure 21. One problem with the current solution is the frame of the tablets skews the image, making it harder to solve the puzzle.

Figure 20: Start screen in Pearls 'n' Pirates where players choose a team to play in together.

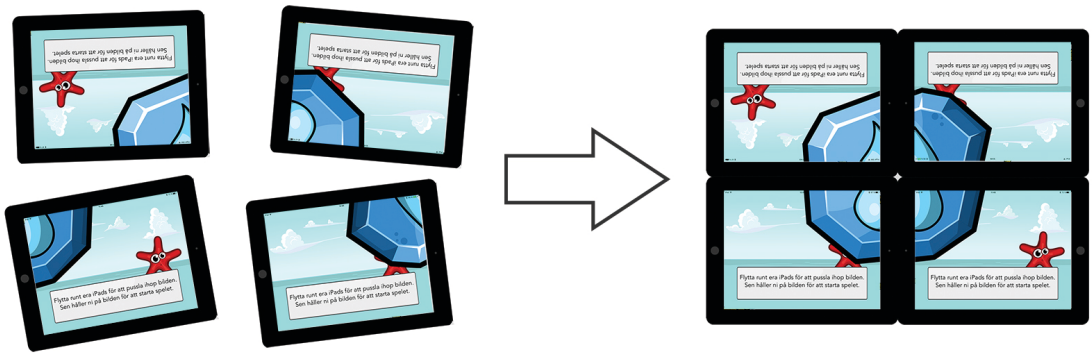

Figure 21: Screen from Pearls 'n' Pirates setup where players solve a puzzle to arrange the tablets in the correct order.

4 Summary of appended papers

This section will give a short overview of the papers included as part of this thesis.

4.1 Paper 1: Designing technology for and with developmentally diverse children – A Systematic Literature Review

The starting point for this paper was the need to understand how developmentally diverse children are typically involved in the design process, focusing on methods, techniques, and approaches for involving them, but also on the roles that the children or adults e.g. teachers, and parents, have in the design process.

A systematic literature review was conducted in which 325 candidate papers were analysed twice, resulting in a final list of 88 papers relevant for the literature review. From these papers, data describing the involvement of developmentally diverse children in the design process was gathered, e.g. the *phases of inclusion, methods and techniques* used in each phase, and the *age* and *disability* of the children involved.

The findings in this paper were already presented in section 2.5, Designing for and with developmentally diverse children, and will therefore not be repeated here.

4.2 Paper 2: The Role Definition Matrix: Creating a Shared Understanding of Children's Participation in the Design Process

The idea for this paper emerged during the work with the literature review, in which we tried to apply Druin's model of children's role in the design of technology (2002), to describe children's participation in the design process. This identified the need for a new model better suited for this and therefore a new model was iteratively developed, discussed and tested by the researchers.

Using Druin's model (2002), it can be hard to cover all possible ways in which children can be involved in the design process, something that is also acknowledged by Fails, Guha and Druin (2013). The role of design partner can be hard to live up to, as many researchers are unable involve children over several years, allowing them to be equal stakeholders in the process. For the role of Informant, the problem is that it is not very clearly defined, and becomes very broad, e.g. it can be used to both describe children being observed, or to describe children being involved in a design activity. As testers, it can be problematic to model the participation as testing can be done with more or less influence from the children.

The outcome from this paper was the Role Definition Matrix (see Figure 22), based on two underlying dimensions; the phases of the design process (requirements, design, and evaluation), and the activity in relation to the designer (indirect, feedback, dialogue, and elaboration). The model allows researchers to give a more detailed description of children's involvement in the design process.

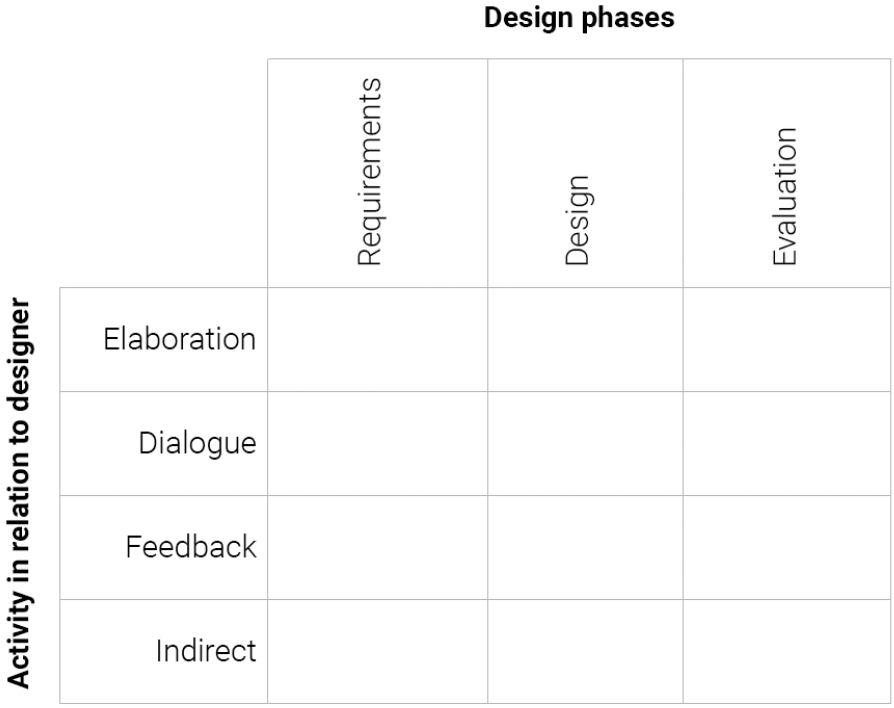

Figure 22: The Role Definition Matrix.

4.3 Paper 3: Legitimate Participation in the Classroom Context - Adding Learning Goals to Participatory Design

This paper argues that actively working with learning goals can increase the transparency of the mutual learning in participatory design, and that activities can be planned and staged in order to meet them.

A study was carried out during a course in which seven project groups of master's students actively involved children in the design of technology. In their projects the students were asked to actively formulate learning goals for either specific activities or for the whole design process, related to the either specific skills *(e.g. math)*, general skills *(e.g. presenting)*, or design skills *(e.g. brainstorming)*. The learning goals should further be communicated to the children, and design activities should be aligned to these learning goals and include moments of reflection.

The study found a set of challenges associated with introducing learning goals in participatory design activities. Examples of identified challenges include: a difficulty to determine good learning goals and to align an activity to these, a difficulty to separate learning goals for an activity from the learning goals for the developed technology, a tendency to choose learning goals based on method rather than the other way around, and lastly that it is not always beneficial or possible to explain learning goals to children before an activity.

4.4 Paper 4: Extended participation - Experiences from building relationships for design with developmentally diverse children and their teachers

This paper reports on the experiences from two years of fieldwork and participatory design workshops in a special education school. Data in the form of field notes, images, recordings, and outcomes of design activities were synthesized with a focus on the relationships in a participant triangle, as presented in Figure 23. Structured around this participant triangle the familiarization process with the children and the process of building a relationship with teachers and assistants were described. The focus was on describing and discussing how these relationships affect each other, how they evolve over time and what effects this may have on design activities.

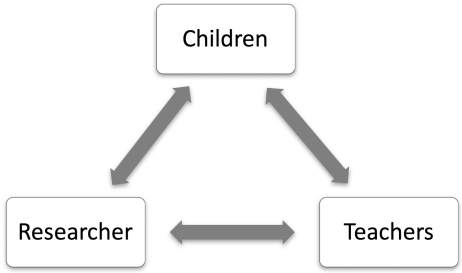

Figure 23: The participant triangle.

The paper shows that the familiarization process takes time and may be very different from child to child. Some children immediately approach and interact with the researcher while for others a teacher may be needed to understand that the familiarization had been successful. Further it can be important to provide different opportunities for the children to engage with the researcher as children seem to prefer different ways of doing this, e.g. to approach the researcher alone or in group, or to do it during class, breaks, lunch or field trips.

With teachers, the development of a relationship can mean that over time the role of the teacher and the researcher start to align. For the researcher, there are certain risks associated with this, as it may conflict with the research goal, and may also raise ethical issues, for example around whether or not this kind of involvement is covered by the informed consent. However, it also provides opportunities for mutual learning, e.g. the teachers start to take an interest in the current research focus and can see the children in new light. For the researcher, it means more involvement with the children during school activities and that knowledge may be gained without conducting design workshops.

For design activities, the paper found that it can be important to involve teachers, especially when children are taking part in design activities in larger groups or when the children are less communicative. This may however affect children's influence on the design process since teachers can have assumptions about what the children want or what they can contribute with. It can therefore be beneficial to sometime involve the children more independently in design activities.

5 Results

The results and synthesis of the work in this thesis will be presented through a tentative model that describes different stages for conducting research- and design activities in a school context.

5.1 The D^{3}iSC model

The D^{3}iSC model (***D****esign for and with* ***D****evelopmentally* ***D****iverse Children* ***i****n a* ***S****chool* ***C****ontext*) describes the different stages when conducting research- and design activities with developmentally diverse children in a school context focusing both on the relationships and understanding developed between researcher and children, and between researcher, and teachers or assistants. The tentative model consists of five stages; Access, Acceptance, Understanding, Involvement, and Alignment, which all enable different forms of participation (see Figure 24). These stages are described in detail below.

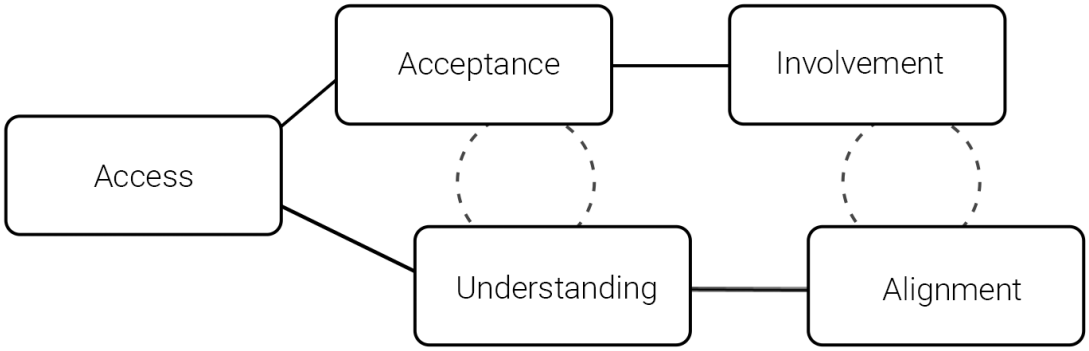

Figure 24: An overview of the stages in the D^{3}iSC model and their relationships.

5.1.1 Access stage

The first stage is the one in which a researcher tries to establish contact with a school in order to be able to conduct research- and design activities (see Figure 25). In this stage, both the researcher and the research goals represent elements of uncertainty and unfamiliarity for the different stakeholders. At this stage, the researcher has no contact with the children. Instead is it other stakeholders, e.g. the class teacher, the school principal, and parents that allow access to the school. In order for access to be granted, the perceived value of establishing contact must be greater than the expected cost in terms of the effects on the children's well-being, and the disturbance of the daily practice of the school. This value can lie both in the research outcomes and the research process.

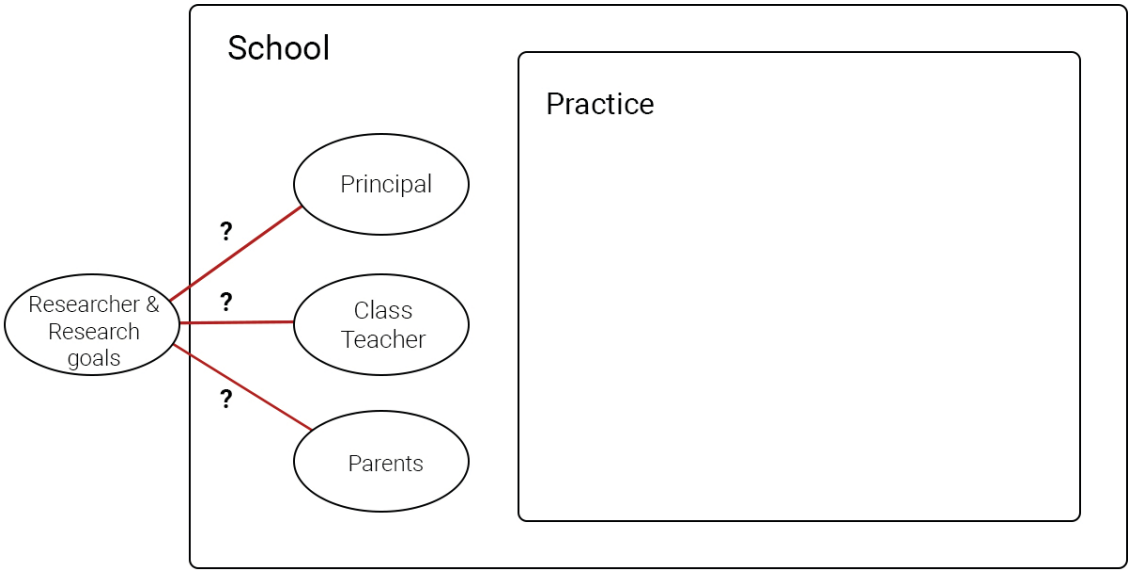

Figure 25: The access stage in which the researcher aims to establish contact with a school and get access to the school context.

Gaining access

Class teachers are important stakeholders when it comes to establishing contact with a school to get access to the children, as they often have a veto in allowing the researcher access. They can also have a facilitating role towards parents, other teachers and assistants, and an enthusiastic teacher can help with pointing out the value of the contact to other stakeholders. The researcher's experience is that the principal will often agree to access if there is an interested teacher arguing for it. Examples of topics and concerns from teachers associated with the perceived value and cost of granting the researchers access, can be seen in Table 1 below.

Parents are often only reached through the written material sent to get informed consent so this must be comprehensive enough to explain what the aim of the research is, what kind of research activities will take place and how the children will be involved in order for them to see the value. If possible, the researcher could take part in a parental meeting at the school to meet in person and inform about the research project.

Topic of concern	**Perceived value and cost**
The research The aim of the research and especially planned research- and design methods	Research with a clear outcome that can positively affect their practice has a greater value than e.g. collecting data. Explorative research with loosely defined methods has less obvious value and more costs than a well-defined approach. Methods with a smaller impact on daily practice (e.g. observations in classroom), have lower perceived costs than methods with more active involvement from children.

The researcher The researcher's knowledge about, and experience with developmentally diverse children.	Experience can be a difficult hurdle at the outset, and an in-experienced researcher should aim for well-defined methods with low involvement from the children. Concerning knowledge, the researchers should be clear what expertise they will bring with them and what they want to learn from the teachers, the children and their daily practice.
Learning New experiences or learning opportunities.	Teachers will perceive a greater value in their participation if they see opportunities for learning or new experiences for the children or themselves. Discussing or suggesting learning goals can help with identifying such opportunities, as described in Paper 3.
Technology View on technology	Both teachers' and researchers' values concerning the use of technology in education are important to identify and communicate. For example, while researchers may hold the view that technology is to be used as support or motivation for children to take part in activities, without any discussion about values, teachers may think the researchers aim to develop technologies to replace school staff, or reduce the child's possibilities for interaction with other children or adults.

Table 1: Common topics and concerns from teachers associated with the perceived value and cost of allowing the research access.

5.1.2 Acceptance stage

In the acceptance stage the researcher has gained access to the school context, but once again represents an element of uncertainty and unfamiliarity to teachers (that did not take part in the first stage), assistants, but especially the children (see Figure 26). Before acceptance is established, research goals are in the background, and research activities may be limited to ones where children are involved indirectly, e.g. observations of daily practice. For the researcher, the focus is thus on gaining acceptance and building relationships in order to get closer to the practice in school, and to be able to involve the children in design activities.

Gaining acceptance

For the children, the acceptance and familiarization process can be very different from one child to the other. As described in Paper 4, some children may immediately approach the researcher while others need time and different opportunities to engage with the researcher. Some children prefer to approach the researcher during class, breaks, lunch or field trips or to do it alone or supported by a teacher or peer. Some children may choose to not interact with the researcher at all, but may very well have accepted them to take part in school activities.

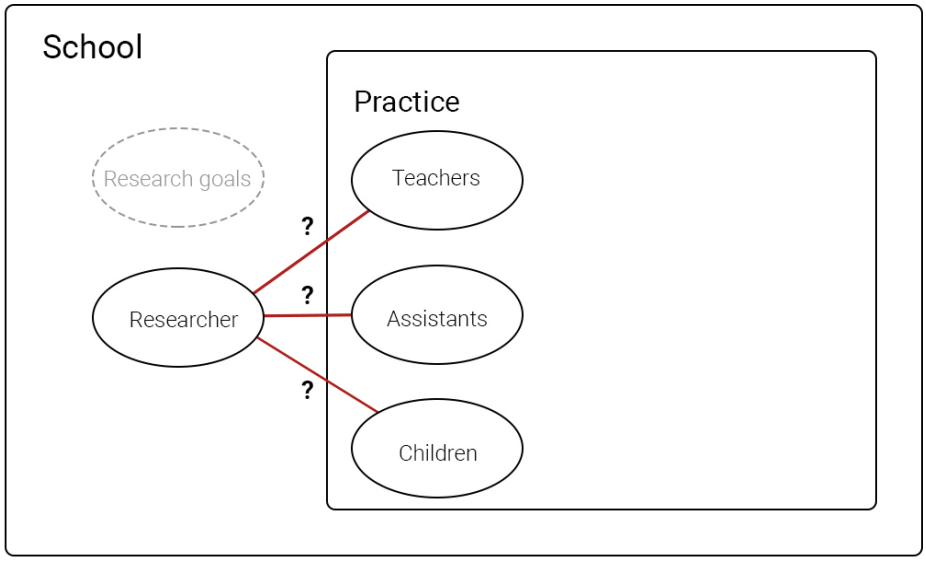

Figure 26: The acceptance stage in which the researcher aims to get acceptance from children and school staff to get closer to the practice in school.

Acceptance between the class teacher[3] and the researcher is often reached in the access stage, and the relationship is maintained due to the close contact between them. Getting initial acceptance from the other teachers and assistants at the school is not that complicated either. The class teacher may help to facilitate the acceptance and in communicating the perceived value of the contact to the other teachers and assistants. It can however be a challenge to maintain these relationships, as time in school is often limited and focus is often on building a relationship with the children.

Research and design activities

When children are included indirectly as described by the Role Definition Matrix (Paper 2), being merely observed either in a natural context or observed doing something, e.g. testing an application, it is often enough with low acceptance. However, it is important to realize that if acceptance has not been reached it can affect the outcome of an activity. For example, children may be more occupied with keeping track of what a researcher is doing rather than focusing on the task at hand.

Once more acceptance is gained from children and teachers, it is possible to hold activities where children are involved more actively e.g. in dialogue or giving feedback (Paper 2). However, it may not be possible for the researcher to directly facilitate the activity but may require a teacher to do so. In addition, the researcher may need help from a teacher in choosing methods that can be used with the children, and in understanding how the children will need to be supported in order to take part in the activity. The activity probably still needs to conform a lot to the daily practice of the school. Lastly, the researcher may require the help from a teacher to review the activity and discuss and understand the outcomes of it.

[3] The teacher does not have to be a class teacher but could be any teacher that “owns” the research project at school and is the main contact for the researcher.

5.1.3 Understanding stage

The understanding stage is reached once acceptance has been gained, and in this stage, the focus is twofold. First, the researcher aims to understand e.g. the activities, routines, structures, values, relationships, etc. that form the practices in the school context but also to understand the children's strengths and needs (see Figure 27). Second, the focus should be on making sure the children, teachers, and assistants understand what the goals and underlying values of the research or the technology under development are.

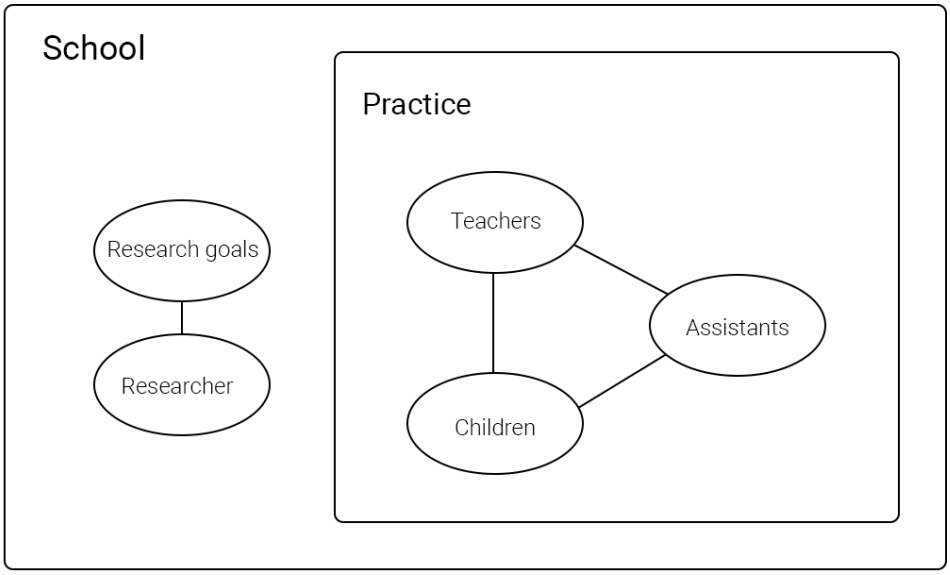

Figure 27: The understanding stage in which the researcher focus on understanding practice and on making the research goals transparent to children, teachers, and assistants.

Gain understanding

In order to get a thorough understanding of practice it can be important to take part in different activities with different teachers, assistants, and constellations of children. As described in Paper 4, children can often behave differently in different situations, e.g. during class, breaks, lunches, and fieldtrips. Additionally, teachers and assistants may structure activities, or interact with the children in different ways, and children may be affected by the dynamics of a group.

The class teacher is often introduced to the goals and values of the research during the access stage, and as the relationship between the researcher and class teacher relies on close contact, it is often easy to keep the class teacher informed about the current research focus. For the other teachers and assistants this is often more challenging, which is related to the problem of maintaining a relationship with them as described for the acceptance stage.

Research and design activities

A greater understanding of practice from the researcher's part reduces the dependency on teachers to choose methods, to understand what support the children require to take part in the activities, and to review the activity. However,

teachers and assistants may still need to take part in or even facilitate the activities, as the children may not feel comfortable to interact with the researcher independently. Therefore, it is important that the designer's values are transparent, and that everyone involved understands the desired outcomes of an activity, e.g. that is more important to learn what engages children in games, rather than coming up with a working concept.

Making the children understand the goal of the research is challenging. What is understood is often the tangible outcome, e.g. that they will be part of making an application. It can similarly be hard to explain the outcomes of a design activity and to manage their expectations. For example, during game ideation it can be hard to for the children to understand that the outcome will not be their verbatim idea of a game, but rather a game based on their ideas and what they find engaging.

5.1.4 Involvement stage

In the involvement stage the researcher may become part of the practice in school (see Figure 28). The level of involvement often gradually develops and there is often a continuum between acceptance and involvement.

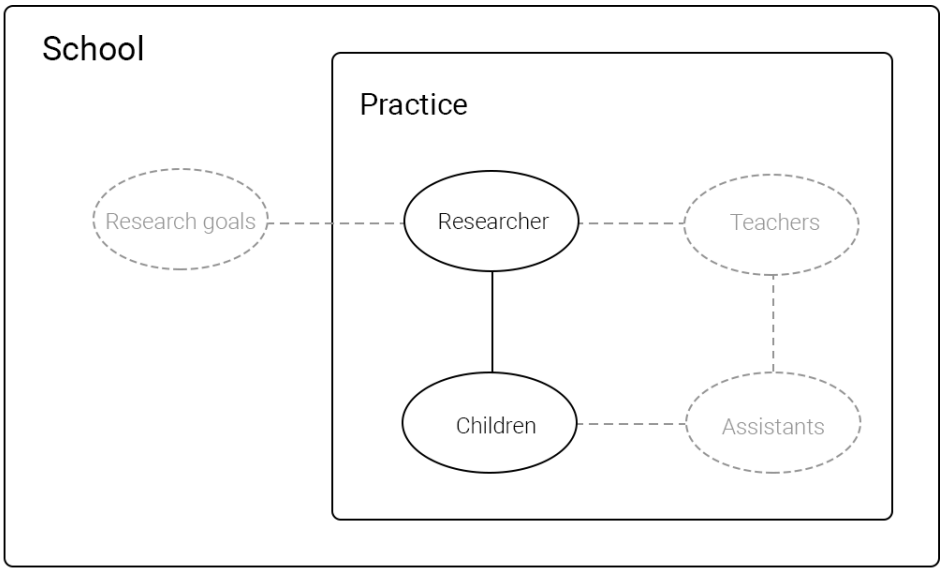

Figure 28: The involvement stage in which the researcher becomes part of the practice and approaches the role of the teacher.

Developing involvement

After acceptance, the researcher may initially take part in play with the children during breaks or be part of class discussions. Eventually, the researcher may be invited by the teacher to help the children with smaller tasks during class, e.g. cutting with scissors, to later on approach the role of the teacher more and more, for example in assisting the children in solving math problems. This process may take time, and depends a lot on the teachers' and children's willingness to allow the researcher to be part of their practice.

Being part of the practice rather than just observing allows the researcher to interact and talk with the children more directly. Eventually, involvement could lead to the researcher being able to spend time alone with the children which can increase the understanding of how children interact with each other without a teacher close by, e.g. how they may get into conflict, and when and how they lose focus. Involvement can also make the children more comfortable interacting with the researcher on their own, which could enable them to take part in design activities with less support from teachers or assistants.

In this process, the researcher also approaches the role of the teacher. As discussed in Paper 4, the researcher often gains a better understanding of what the children struggle with and challenges associated with teaching it. However, there is a risk that involvement could conflict with research goals, or that the children start perceiving the researcher as a teacher which could be problematic in design activities due to the power structures between teachers and children (Druin, 2002).

Research and design activities
The more familiar the researcher is to the children, and the more their relationship develops, the more comfortable the children are to talk and interact with the researcher and vice versa. This reduces the need for support and help from teachers and assistants during design activities. In addition, as involvement can often lead to more knowledge about the practice as well as the children it can be easier to relate to their strengths and interests.

5.1.5 Alignment Stage

The alignment stage describes how the teacher may start aligning with the role of the researcher, and make the research goals part of the practice (see Figure 29). As with the involvement stage this happens gradually and there is a continuum between understanding and alignment.

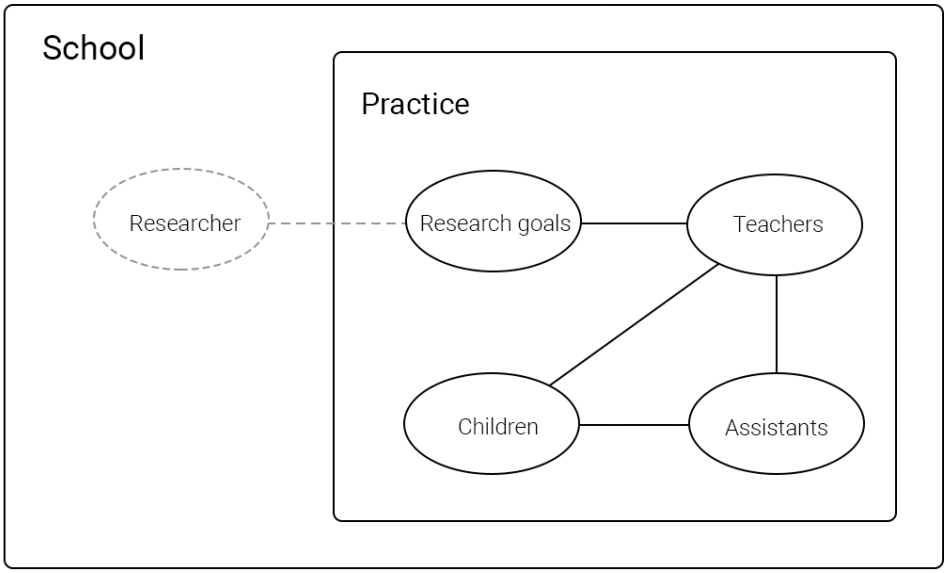

Figure 29: The alignment stage in which the teachers aligns with the role of the researcher and make the research goals part of the practice.

Developing alignment

The level of alignment depends on the teacher's or assistant's interest in the research, but also on the researcher's ability to communicate the goals and underlying values of the research, as well as the researcher's interest in the practice. As described above, the close contact and frequent discussions between the researcher and the class teacher about design- and school activities and their outcomes can lead to a close alignment. However, reaching the same level with other teachers and assistants may be more challenging. Conducting activities for school staff e.g. focus groups, where a mutual understanding can be developed, can help with making the goals and associated values of both the research and the technology to be developed more transparent. These activities also allow adult stakeholders to be seen, and voice their opinion and values.

Research and design activities

Alignment can affect research and design activities in two ways. First, a teacher may help the researcher in advance by preparing the children for coming activities. For example, if the goal is to test and give feedback on different existing applications, the teacher may hold school activities in which the children practice giving reviews on e.g. short movies.

Additionally, the researcher's experience is that a teacher who is aligned with the research goal may rearrange, restructure, or even invent new forms of school activities in order to investigate the research problem together with the researcher. This can allow the researcher to gain a lot of design knowledge without conducting specific design activities, as the school activities and practice are adapted towards the current focus of the research. For example, the teacher may hold a class discussion about emotions, or ask the children to collaboratively design a sandcastle.

6 Discussion

Conducting research- and design activities with developmentally diverse children and their teachers in a school context can be complex. The school context can provide structure and familiarity as the routines, values, and relationships with teachers and other children form a practice in which children feel safe and secure, and know what to expect. Structure and familiarity are two important factors for involving children in school as described by for example by Benton et. al (2014), and Holone and Herstad (2013). As shown in Paper 1, the most prominent context for involving developmentally diverse children in design of technology, is the school context. However, in this context, methods also needs to conform to practice in school, e.g. routines and structure *(e.g. usual length of activities, usual group size and composition)*, support needed *(e.g. from adults, instructions, etc.)*, but also values (Iversen, Halskov and Leong, 2010) in that practice (*e.g. view on technology and learning, or willingness to explore and try new things).* Therefore, the relationships and mutual understandings are important, not only between researcher and children as described by e.g. (Piper *et al.*, 2006), but also between researcher and teachers or assistants (Holone and Herstad, 2013).

The results of this research have been synthesized in a tentative model for describing Design for and with Developmentally Diverse Children in a School Context (D^3iSC), which describes the different stages in a design process related to different levels of relationship and understanding, and how those may affect design activities. The D^3iSC model complements other models and frameworks, e.g. Children in the Centre Framework (Kärnä *et al.*, 2010), and the Diversity for Design Framework (Benton *et al.*, 2014).

The Children in the Centre Framework, emphasizes the importance of putting a child's interests, strengths and needs at the centre during design activities. In order to achieve this, it is explained that children, their families, tutors and researchers need to work together. The D^3iSC model can complement the Children in the Centre Framework by describing the different stages of the relationships and mutual understanding that have been developed between the stakeholders, and also how this may affect the outcomes of different activities.

The Diversity for Design Framework describes how a researcher need to understand both the neurodiverse culture they are designing for, as well as the individual children in order to structure environments and provide support in design activities. The framework suggests to complement theoretical views on the neurodiverse culture with e.g. observations and interviews, and states that it is important to identify children's ability levels, hobbies, and interests in advance, as well as the need for a familiar adult to take part to provide structure and additional support. Here, the D^3iSC model can provide an understanding of when and how this information can be collected and how, from the children, their teachers, or through observation. Further the model can describe and explain the relationship between the children, teachers, and researcher, which will affect the level of support needed in a design activity.

As the model is tentative and based largely on the research described in this thesis, it can be hard to directly generalize from it. There are some important limitations related to this that need to be addressed. First, the fieldwork in this thesis has been quite extensive with the most closely involved school being visited about forty times during two years. It is recognized that most research and design projects will not have the resources or time for this kind of involvement. However, a strong relationship and level of mutual understanding could probably be developed over a shorter time. The D^3iSC model can assist both with learning how the different stages are reached, and how the different stages may affect the outcome of a design activity conducted in that stage.

Second, the research described took place in the context of Swedish compulsory school for children with learning disabilities, where mixed groups of children with varying disabilities all attend the same class. In contexts where the children all have similar or more severe diagnoses, the results may be different. Additionally, the most closely involved school had a very open attitude towards granting access, and in allowing the researcher to be part of the practice, even though the scope of the research was quite wide, and the approach was explorative. The model is also limited by a focus on the initial phases in the design process, requirements gathering, ideation, and early design. It is possible that for activities where children are involved in different forms of evaluation, relationships and mutual understanding are less important.

One could also discuss whether or not the scope of social and emotional learning framing the research and design activities, has been significant in forming the model. The results show that it is important to take part in different lectures and activities both to build a relationship with children, but also to gather design knowledge. However, one can question if it would be equally important or beneficial for someone designing for example a math game to take part in different lectures, breaks, and activities. An argument in favor for this is that it allows a designer to not only build the relationships that allow children to take part in design activities, but also provides a more holistic understanding of practice. This can help the designer learn how things are taught in different situations and more importantly, how they are understood by the children. As an illustration, during the fieldwork for this thesis it has been observed how mathematics and physics have been explained by teachers and discussed with children during breaks in relation to e.g. throwing, or bouncing a ball, and how children explain programming statements in Scratch to each other by role-playing.

6.1 Future work

The research described in this thesis concerning the involvement of developmentally diverse children, teachers, and assistants in the school context will continue. More concretely, the later stages of the design process will be explored by continuing the development of the different concepts described in this thesis, and involving children, teachers and assistants in different forms of evaluations.

The focus of the technology to be designed and evaluated will be on collocated collaborative games which can provide the children with mixed spaces (Slovák and Fitzpatrick, 2015) in which they can practice skills related to this. In addition to the developed technology, and contributions related to involving developmentally diverse children in different forms of evaluation, the research could also contribute to an understanding the connections between game mechanics and different social and emotional skills that are addressed through the games.

7 Conclusion

The research presented in thesis concerns how to involve developmentally diverse children, as well as their teachers and assistants in the design process of technology. The focus has been on the school context, which can provide structure and familiarity, which can be important to enable developmentally diverse children to take part in design activities. In the process of adapting and conforming design activities to the practice of school, the relationships and mutual understanding between the researcher and children, and between researcher and teachers or assistants stand out as important. To describe these relationships, the mutual understanding, and the roles that children, teachers, and assistants play during the design process, the research is synthesized in a tentative model for describing Design for and with Developmentally Diverse Children in a School Context (D^3iSC).

The D^3iSC model shows that in gaining access, it is important that the perceived value of taking part in the research outweighs the costs in terms of the effects on the children's well-being, and the disturbance on the daily practice of the school. Once a researcher has gained access, it is important to gain acceptance from children, teachers, and assistants, and to build up an understanding of the context. With acceptance and a limited understanding the researcher will be able to conduct design activities but will rely a lot on teachers in planning, reviewing or even facilitating the activity. Building a stronger relationship with both children and teachers, will result in a deeper understanding of the practice, which can be important both to understand design requirements but also in outlining the design activities and for enabling children to take part in design activities more independently.

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