Designing technologies for and with children

Theoretical reflections and a practical inquiry towards a co-design toolkit

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DESIGNING TECHNOLOGIES FOR AND WITH CHILDREN

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Summary

Giving those who are destined to use a product or service a critical role in its design is a core tenet of the Participatory Design (PD) tradition. PD is characterized by a process of reciprocal learning, co-realization, and the sharing of decision-making power among relevant stakeholders in the design process, including envisioned users. PD practices often incorporate generative techniques, such as co-design, which enable participants to externalize and embody their thoughts and ideas by the act of making artifacts.

In the Child Computer Interaction (CCI) community, children are often involved passively in the design of technology (e.g. as testers). Through the growing use of PD practices, children have become active contributors to the design process, co-determining the direction and the final design outcome. However, two particular issues are insufficiently addressed in the CCI community.

The first issue relates to challenging group dynamics that limit children's participation in design and hamper their creative abilities. If this problem is addressed at all, CCI researchers tend to focus on remediating asymmetrical power relationships between adults and children, while neglecting group dynamics between children themselves. The second issue concerns the analysis of children's contributions in co-design activities. The CCI community lacks robust methods to integrate visual and tangible dimensions of co-design artifacts, and their verbal explanations into a coherent analysis. The unilateral focus on the verbal explanation implies that co-design techniques are regarded as a direct means to access children's perspectives (cf. naive empiricism). In addition, interpretative approaches that aim to go beyond the surface level of children's ideas often lack rigor and transparency.

To address these issues, this PhD project combined a research through design and case study research approach. Based on insights derived from a review of the academic literature and four case studies with 9- to 10-year-old children, the research resulted in a co-design toolkit. The first part of the toolkit presents CoDeT (Collaborative Design Thinking), a co-design procedure that builds on the theoretical models of Social Interdependence Theory and Design Thinking. With the CoDeT procedure, design researchers prepare and conduct co-design activities with children that account for challenging group dynamics. The procedure is especially useful for high child-to-adult ratios (1 adult for 15 to 20 children) such as in a school context. CoDeT is unique in how it structures sufficient work-group features and strengthens children's Design Thinking abilities in co-design activities. In the toolkit, the different steps of the procedure are presented in a 'what why how' structure, offering concrete

instructions as well as in-depth information about why these steps are important. CoDeT is therefore a flexible procedure that can be used in a broad range of design contexts.

The second part of the toolkit presents GLID (Grounding, Listing, Interpreting, Distilling), a method that relies on a values-led approach to PD, Multimodality, and Means-end Theory. GLID identifies children's underlying values embedded in co-design out-comes resulting from CoDeT. With GLID, value conflicts between children and other stakeholders can be accounted for, shifting the focus to what endures beyond interaction, that is, the outcomes and lasting impacts of technology. Another characteristic of GLID is its thorough consideration of different modes (tangible, visual, textual, et cetera), which are analyzed for similarities and differences. As with the CoDeT procedure, the toolkit presents GLID in a 'what why how' structure. The method provides detailed guidelines for design researchers to analyze co-design outcomes in a transparent and coherent way, beyond the surface level of children's ideas.

Together, the CoDeT procedure and GLID method comprise a holistic approach to involving children as design partners at the early stages of technology design.

Samenvatting

Toekomstige gebruikers van een product of dienst een kritische rol geven in het ontwerpproces is een basisprincipe van de Participatory Design (PD) traditie. PD wordt gekenmerkt door symmetrisch leren, co-realisatie en het delen van beslissingsrecht met alle belanghebbenden in het ontwerpproces, waaronder toekomstige gebruikers. Vaak gebruikte technieken in PD zijn generatieve technieken zoals co-design. Met behulp van co-design veruitwendigen participanten hun ideeën en waarden met betrekking tot (toekomstige) technologie door het construeren van fysieke artefacten.
In de Child-Computer Interaction (CCI) community krijgen kinderen vaak een passieve rol toebedeeld in het ontwerpproces van technologie (bv. als testers). Onder invloed van de PD traditie neemt hun invloed op de richting en uitkomst van het ontwerpproces ge-staag toe. Twee specifieke uitdagingen komen echter onvoldoende aan bod in de CCI community.
Een eerste uitdaging heeft betrekking op problematische groepsdynamieken tijdens co-design activiteiten. Deze dynamieken kunnen de participatie en creatieve vaardigheden van kinderen negatief beïnvloeden. Als er al aandacht is voor dit probleem, dan wordt er gefocust op het remediëren van asymmetrische machtsverhoudingen tussen volwassenen en kinderen, maar problematische groepsdynamieken tussen kinderen worden genegeerd.
Een tweede uitdaging betreft de analyse van de bijdragen van kinderen tijdens co-design activiteiten. Vooralsnog ontbreken robuuste methoden om de visuele en tastbare dimensies van co-design artefacten en hun verbale uitleg te integreren in een coherente analyse. De unilaterale focus op de verbale uitleg impliceert dat co-design technieken worden beschouwd als een directe toegang tot de leefwereld van kinderen (cf. naïef empirisme). Bovendien missen interpretatieve benaderingen die voorbij het oppervlakte-niveau van de ideeën van kinderen gaan transparantie en systematiek.

Om deze uitdagingen aan te pakken combineert dit onderzoek een Research through Design en case study research aanpak. Op basis van een literatuuronderzoek en vier case studies met 9- en 10-jarigen werd een co-design toolkit ontwikkeld.
Het eerste deel van de toolkit presenteert CoDeT (Collaborative Design Thinking), een co-design procedure gebaseerd op Social Interdependence Theory en Design Thinking. Met behulp van de CoDeT procedure kunnen design onderzoekers co-design activiteiten met kinderen voorbereiden en uitvoeren, en anticiperen op problematische groepsdy-namieken. De procedure is in het bijzonder geschikt voor hoge kind-volwassenen ratio's (15 tot 20 kinderen per volwassenen) zoals in een school context. CoDeT is uniek in hoe het de

samenwerking tussen kinderen faciliteert en de creatieve vaardigheden van kin-deren aanscherpt. De toolkit beschrijft de verschillende stappen van de procedure in een 'wat, waarom en hoe' structuur, en biedt naast concrete instructies ook verdiepende achtergrondinformatie. Dit maakt van CoDeT een flexibele procedure die kan worden ingezet in uiteenlopende design contexten.

Het tweede deel van de toolkit presenteert de GLID (Grounding, Listing, Interpreting, Distilling) methode die gebaseerd is op een waarden-gedreven PD aanpak, Multimodality en Means-end Theory. GLID heeft als doel om de onderliggende waarden van kin-deren, vervat in co-design uitkomsten, te identificeren. Met behulp van GLID kunnen waardenconflicten tussen kinderen en andere belanghebbenden in rekening worden gebracht. Hierdoor verschuift de focus tijdens het ontwerpproces van de interactie met technologie naar de langdurige impact van technologie. Een ander kenmerk van GLID is het vergelijken van verschillende modaliteiten van co-design uitkomsten (tastbare, visuele, tekstuele, et cetera.) om overeenkomsten en contradicties bloot te leggen. De toolkit beschrijft de verschillende stappen van de GLID methode eveneens in een 'wat, waarom en hoe' structuur. Aan de hand van gedetailleerde richtlijnen kunnen design onderzoekers co-design resultaten op een transparante, coherente en verdiepende manier analyseren.

De CoDeT procedure en de GLID methode bieden samen een holistische aanpak om kin-deren een stem te geven in het ontwerpproces van technologie voor kinderen.

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Introduction

The overarching research question in this PhD study is how to involve children during the early stages of design in a meaningful and appropriate way. Giving children a voice in the design of technology that will ultimately have an impact on their lives is a core tenet of the Participatory Design (PD) tradition. Although PD lacks a strict definition or set of rules, it is often described as an approach in which the people who are destined to use a product or service play a critical role in designing it. This is achieved through a process of reciprocal learning, co-realization and the sharing of decision-making power between all relevant stakeholders, including envisioned users and design researchers.

In the Child Computer Interaction (CCI) community, children were initially involved rather passively in the design of technology (e.g. as testers). Under the influence of PD practices more equal partnerships have been developed. Instead of merely extracting knowledge from children to inform the design process, children have become active contributors who co-determine the direction and the final outcome of the design process. Often used are generative techniques such as co-design that rely on inventive and imaginative processes, and focus on how children give meaning to their experiences and engage in world making in their everyday lives. In small teams, children are assisted to construct designerly artifacts, and to tell a story about what they have made and why. In this way, children are enabled to give meaning to their experiences, and to collectively explore and express future ways of living.

Building on this emerging tradition of designing technology for children with children, we focus on two particular challenges that have been insufficiently addressed in the CCI community. Firstly, we look at how collaboration between children can be structured more efficiently in co-design activities. Co-design techniques are based on the assumptions that everyone can contribute creatively to the design process and that opening up creativity will increase positive outcomes. However, the occurrence of challenging group dynamics may limit children's participation in design and hamper their creative abilities. The first research question therefore addresses how to scaffold collaboration in order for children to make meaningful contributions.

Secondly, we address the problem of interpreting the outcomes of co-design activities in a transparent and systematic way beyond the surface level of children's ideas. We are particularly interested in how the visual and tangible dimensions of co-design artifacts can be interpreted in relation to verbal explanations and the context in which they were created. In this way, we want to arrive at a richer and more holistic understanding of children and strengthen their impact on the product or service being designed. Building on insights from literature and multiple case studies, the goal of this PhD study is to develop a practical toolkit to address both challenges in co-design activities with children.

The first part of the thesis is divided in six chapters and discusses theory, method and practice. The first chapter gives an overview of related work by discussing PD's history, the main characteristics and directions for the future. Afterwards, a broad overview of existing approaches to involve children in design processes is presented, and important challenges are highlighted. The second chapter elaborates on the research questions, target group, research methods and goals. In the next three chapters, the theoretical building blocks are discusses used to develop the co-design toolkit. The third chapter elaborates on how values (in addition to ideas) can serve technology design, the fourth chapter discusses the concept creativity and the importance of Design Thinking in co-design, and the fifth chapter sheds more light on the concept collaboration by looking at the field of education. The sixth chapter discusses how the insights from literature were applied to co-design activities with children by offering a reflective account of four case studies. In a linear fashion, it tells the story from our initial research questions until the development of the co-design toolkit, and discusses how we expanded and took forward our knowledge from one case study to the next. In order to do so, cross-references are made with academic literature in the first part of the thesis (chapters 1, 3, 4 and 5) and the output chapters in the second part of the thesis (chapters 7, 8 and 9), and some previously discussed theories and concepts are reiterated to make a coherent story.
The second part of the thesis is divided in three chapters and presents the research output. Chapter 7 presents three published papers dealing with the first research question on scaffolding collaboration and mitigating challenging group dynamics between children in co-design activities. Chapter 8 presents one published paper and one manuscript under review. Both publications tackle the second research question on how to analyze co-design outcomes in a transparent and systematic way. Chapter 9, in turn, presents a co-design toolkit consisting of two interrelated methods. The first part of the toolkit consists of the CoDeT co-design procedure to prepare and conduct co-design activities with children. The CoDeT co-design procedure for preparing and conducting co-design activities with children. Here, an emphasis is put on challenging group dynamics when designing with children. The second part of the toolkit is the GLID method to analyze co-design outcomes based on a concern for values. The two methods provide an answer to the research questions and are a culmination of the insights of the academic literature review (chapter 1, 3, 4 and 5) and the four case studies (chapter 6). Finally, we discuss the overall results and limitations of our study in a concluding section and indicate future research trajectories.

PART 1: THEORY, METHOD AND PRACTICE

1. Participatory Design with children

1.1 Introduction

Participatory Design (PD) is an "approach towards computer system design in which the people destined to use the system play a critical role in designing it" (Schuler and Namioka, 1993). It is a diverse field that draws on different disciplines including social sciences, software engineering and design. This diversity has not lent itself to a single theory, paradigm or approach to practice, which has led to confusion about what it is that makes a design process genuinely participatory (Iversen et al., 2010).

The vagueness surrounding the concept of PD is reflected in the often used description of PD as "a set of theories, practices and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities" (Muller, 2002 relying on Greenbaum and Kyng, 1991; Muller and Kuhn, 1993; Schuler and Namioka, 1993). In this description, the word full is critical since end-users ought to have a substantive say in the final outcome of the design process, which implies the sharing of decision-making power between designers, researchers and end-users. The word end-users, in turn, refers to those who will ultimately use the product or service, but may also refer to other stakeholders in the design process. Especially for novice practitioners in the field, deducing these nuanced meanings from such descriptions is difficult. However, despite the vagueness surrounding the concept, and the lack of a strict definition or some fixed rules, PD is characterized by a commitment to a set of core principles informed by a rich heritage: having a say, mutual learning and co-realization (Bratteteig et al., 2013).

In what follows, we will first give a brief overview of PD's history and we will discuss PD's core principles and characteristics. Then, we will elaborate on the different techniques and tools used often in PD practices, and we will briefly talk about PD's limitations and possible future directions.

Empowering children in the design process can be difficult due to Unequal Power relationships between adults and children, and because children are physically and cognitively different from adults (Bruckman and Bandlow, 2002). Despite these challenges, many approaches have been developed to partner with children in the design process, which will be discussed in the next section. The chapter ends with a broad overview of current challenges and concerns with regard to designing technology for children with children.

1.2 Participatory Design: Early roots and development

PD originated in Scandinavia in the 70s and 80s out of a democratic commitment to empower workers in an increasingly computerized work environment. The basic idea was that those who would ultimately have to use or be affected by the implementation of technology in the workplace should have a critical role in their design (Robertson and Simonsen, 2013). The premise to give workers a voice had its roots in society at large. Since the early 60s, various social, political and civil rights movements had been striving for more decision-making power for those affected by these decisions. In Germany and Austria, for instance, citizens were engaged in important issues in what became known as Future Workshops. In the US, burning social issues such as civil rights were ad-dressed through grassroots action, and in the UK, the revolutionary socio-technical approach highlighted the social and political roots of technology (Kensing and Greenbaum, 2013).

In their aim for workplace democracy, early PD projects had a strong political agenda. Motivated by the value of democracy, academic researchers partnered with labor unions to enable workers to co-determine the shape and scope of the technology that had entered or was about to enter the workplace (Spinuzzi, 2005). These early PD practitioners saw themselves as facilitators who attempted to empower workers in making their own decisions (Clement, 1994). They relied on Action Research to alternate between practical interventions to support positive change (design work) and parallel theoretical reflection to create knowledge. The term Action Research was first coined by Lewin to refer to “a comparative research on the conditions and effects of various forms of social action and research leading to social action” (Lewin, 1946). In Action Research, the re-searcher actively participates in the process of social change and conducts a “spiral of steps”, each of which is composed of a circle of planning, action and fact-finding about the result of the action (Lewin, 1946).

Inspired by Action Research, PD’s democratic commitment was a reaction against the dominant scientific management approaches such as Taylorism. These approaches had canceled out workers’ power by automating tasks and deskilling work in favor of higher efficiency and control over the workforce. Characteristic for Taylorism is that work is broken down into discrete, formal tasks that can be optimized, regulated and easily learned by new workers. All discretion and decisions are taken away from the workers since they can no longer determine how to accomplish a task or develop their own tacit knowledge and skills (Spinuzzi, 2005).

The rationalist, cognitive approach that assumes that there is one best way to perform any activity was reflected in early computer system design (Spinuzzi, 2005). Until the late 80s, most computer systems were custom designed following a waterfall model whereby

problems were top-down defined by management with no input from those who used it. When micro-computers, the precursors to desktop computing, emerged in the 80s, the concept users came to the fore and computer systems were no longer solely custom designed. Around that time, the Human-Computer Interaction community (HCI) and its professional association Computer Human Interaction (CHI) began to focus on how interfaces could be designed for presumed users. However, HCI professionals relied on the same cognitive assumptions as earlier computer system design, and developed rigid models of how users think and use technology (Card, 1981). Even when users were invited to test technology, this usually happened in lab settings (e.g. testing an interface design in a lab capturing eye movements) with no attention for the social nature of work (Kensing & Greenbaum, 2013).
The first to reject this single-user cognitive approach was the professional conference group Computer Supported Cooperative Work (CSCW), focusing instead on the cooperative and social nature of work. With the beginning of networked and distributed systems in the late 80s, CSCW introduced social and ethnographic approaches to computer system design, arguing that users should be involved in the context of their own work. What users are actually doing and how they see things became pivotal in computer system design (Kensing and Greenbaum, 2013).

The intellectual foundations of CSCW were provided by Suchman's much-cited book Plans and Situated Actions: The Problem of Human-machine Communication (1987) Suchman argues that computer system design should no longer rely on fixed plans or procedures that direct human action. Plans should be seen as potential resources for human action, whereas the action itself can only be understood as it unfolds in situ. Similarly, user behavior cannot be fully described by plans or formal descriptions because of its situatedness. User behavior is constantly constructed and reconstructed due to dynamic interaction with the material and social worlds. Therefore, the environment should be regarded as an integral part of the cognitive process (Suchman, 1987). PD and CSCW still rely heavily on Suchman's theory of situated cognition and consider decontextualized cognitive approaches as a central fallacy to computer system design. Besides the fact that CSCW focuses on technology in support of collaborative work and that PD has a broader focus, PD and CSCW differ in that PD also examines the political nature of work and its power relations. Despite its earlier roots, PD in the CHI community originated shortly after the second CSCW conference in 1988 when a CHI sub-group organized the first PD conference in 1990 to give voice to the politics behind all design. A dominant, sensitive theme was that of workers and their muted voices (Kensing and Greenbaum, 2013).

From its very beginnings, PD has been an emancipatory approach that does not want to involve users in a one-directional way as informants (e.g. through interviews or focus groups). Users or those who will interact with the technology being designed are involved as legitimate and acknowledged participants in the design process. The early PD practitioners considered having a voice in decision-making processes a basic human right. The ultimate goal was to develop inclusive and democratic design solutions (Robertson and Simonsen, 2013). This ethical stance, that still underlies PD today, stems from a responsibility to the impact of design on people's lives and environments. Often cited in this context are Winograd and Flores: "We encounter the deep question of design when we recognize that in designing tools we are designing ways of being" (Winograd and Flores, 1986).

The political, emancipatory rationales for participation in design went alongside more pragmatic ones: users and designers should work together and learn from each other in order to

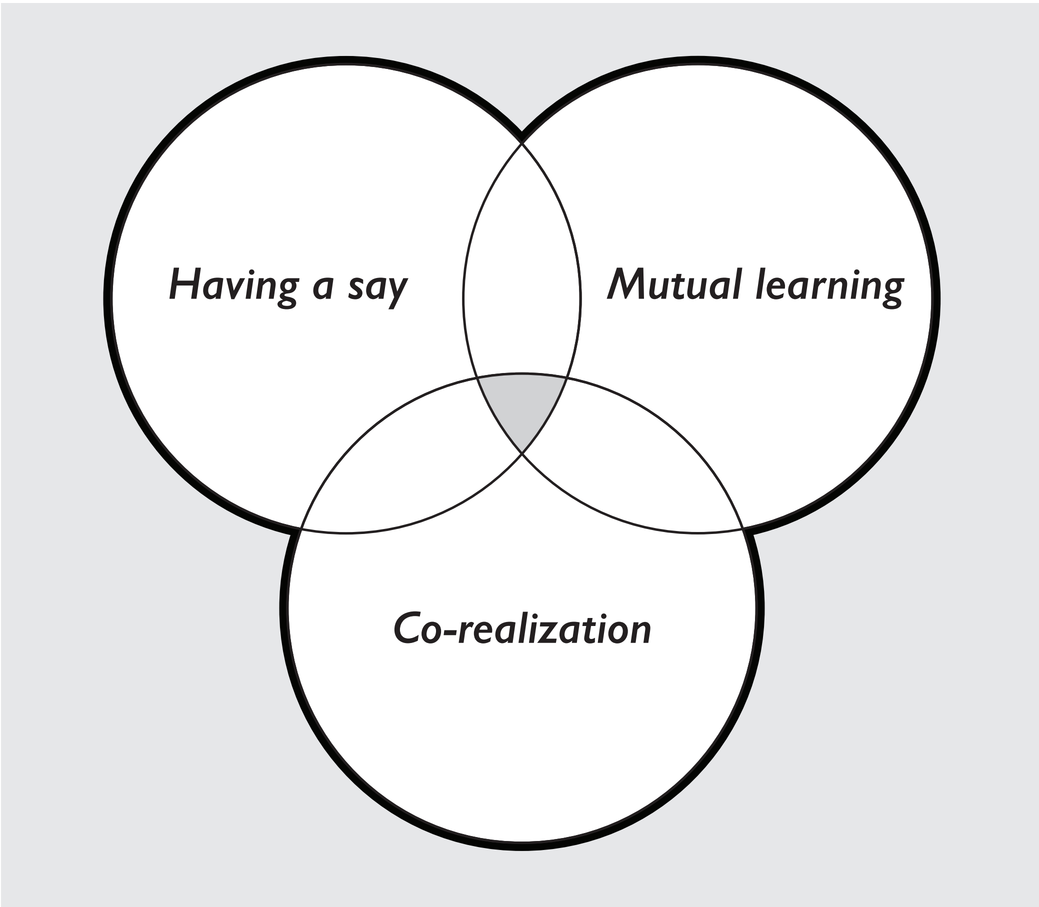

Figure 1: The three core principles or guiding perspectives for PD practices

develop suitable technological solutions. Users were seen as experts of their work domain, and designers as experts of the design process and technology in general. In addition, designers had to adopt the role of facilitator to enable users to express their ideas and visions without the need for a technological language (Robertson and Simonsen, 2013).

To sum up, PD's history started in the early 70s in the form of action-based experiments conducted by university researchers in alliances with organized labor unions. Out of these early experiments, different types of projects emerged in which the foundational democratic motivation was supplemented with a need for different expertises to solve complex design problems. The value placed on user involvement called for new ways of designing and cooperating, which were developed during these early PD projects.

Kensing and Greenbaum (2013) distinguish three types of projects in the early years of PD: knowledge strategy projects, design and intervention projects and ethnographic projects. Knowledge strategy projects focused on the unequal balance between workers who were not used to having decision-making power, and system developers who spoke a technological language that was difficult to understand for workers (e.g. Iron & Metal project in Norway). Design and intervention projects aimed at showing workers that there are technological alternatives that reflect different starting values (e.g. UTOPIA project in Denmark and Sweden). Ethnographic projects, in turn, focused on the relations between work, workers and technology as a reaction to decontextualized studies that prevailed in computer system design around that time (e.g. Xerox Palo Alto Re-search Center in the US) (Kensing and Greenbaum, 2013).

All three types of projects have in common that they took workplace actions and workers seriously, although the problems that needed to be addressed were often undefined as were the methods to solve them. Ethnographic projects were most commonly found in the United States, were a local variant of PD developed (e.g. Blomberg, 1987; Suchman, 1983). Because of weaker labor unions in the US, the focus was on functionality rather than workplace democracy, which resulted in less intrusive methods compared to the Scandinavian tradition. Nevertheless, the pragmatic rationale remained: PD is done with users in a two-directional fashion, not just on behalf of users (Spinuzzi, 2005).

In one of the most well known PD projects conducted in the early 80s, the design and intervention project UTOPIA, design-by-doing methods such as mock-ups and prototyping were developed to enable graphical workers to use their practical skills to participate in the design process. The UTOPIA project focused on typographical issues such as page layout and image processing in the newspaper industry in Denmark and Sweden (Ehn, 1993). The goal was to develop technology for graphical workers that would result in high-quality products, skilled work and a democratic organization of work. The use of non-technical prototyping techniques brought people with different backgrounds together. This hands-on way of working enhanced participant engagement and encouraged communication and shared understanding between the graphical workers, re-searchers and employers.

The cooperative prototyping techniques that were developed in the course of the UTOPIA project have been highly influential in the PD community. Since then, a wide variety of methods, tools and techniques has been developed to enable users, designers and other participants to envision future technologies and practices together. In PD, shared experimentation and reflection are considered essential parts of the design process. Ehn (1993) refers to this practice as "collective reflection-in-action", meaning that the mutual understanding between users, designers and other participants develops and unfolds during the design process, not as detached reflection (Ehn, 1993). This implies that what is being designed in PD is both the technological product or artifact and the process that enables different participants to engage in the design process. Indeed, PD has always had a strong focus on the how of designing throughout its history (Robertson and Simonsen, 2013).

In the early years of PD, most technology was custom-made for the workplace and PD typically addressed small-scale systems. Corporations nowadays are increasingly buying generic software and, at the same time, technology use has expanded into our homes and leisure time. This proliferation of new technologies and domains has widened the scope of PD to, for instance, designing for design after design. Traditionally, PD stopped when the design was handed over to the use context, but many technologies nowadays can also be modified and customized by users. It has become increasingly difficult to anticipate all desirable and undesirable use practices all different use practices, both desirable and undesirable ones. As a consequence, PD literature increasingly includes studies of technology use and reconfigurations of technologies in support of new and unanticipated use. The recognition that design is only completed in use has led to a move towards designing for design after design, whereby aspects of design are deliberately left open as a way to explicitly support the potential for redesign for unanticipated use (Binder et al., 2011).

In addition to this widened scope, PD has achieved a status as a useful commercial approach to developing better consumer products. Involving users and other participants is believed to give better insights, which could not have surfaced otherwise. In this dis-course, PD is often framed as simply a design method to optimize the outcome, that is, a user-friendly and desirable solution. In this pragmatic notion of PD, the decision making power is more likely to remain by the designers whereas sharing decision-making power used to be an explicit goal of PD (Frauenberger et al., 2015). Although this main-streaming of PD has not been greeted by all PD practitioners with enthusiasm, PD has had a profound influence on the recognition and acceptance of the value of user participation in HCI and design in general (Muller, 2002).

1.3 Core principles in Participatory Design practices

Reflecting on PD's rich heritage, Bratteteig and colleagues (2013) distinguish three perspectives or guiding principles that form the backbone of PD: (1) having a say or the sharing of decision-making power between researchers, designers, future users and other stakeholders in the design process; (2) the continual process of mutual learning between these different participants; (3) and the iterative, collaborative development or co-realization of future technologies and practices (see Figure 1). These principles are still relevant today and will be discussed in the next paragraphs.

1.3.1 Having a say

The first principle, having a say, refers to having influence on the actual outcome of the design process, and relates to participation and decision-making power in design (Bratteteig et al., 2013). Having a say goes beyond a one-directional information or listening tour whereby users and other participants can voice their opinions, but the re-searchers and designers make the final decisions, and choose what to take into account and what not in the final design outcome. For researchers and designers it is often difficult to share their decision-making power with future users and other stakeholders, be-cause it may infringe on their autonomy and design expertise, or at least they may experience it that way. At the same time, sharing decision-making power is not only a difficult issue for researchers and designers, but also for those (i.e., future users and other stakeholders) who were not used to having this power. Shared decision-making power implies shared responsibility for the direction and outcome of the design process, something most are not familiar with and which can make them feel uncomfortable. However, the underlying democratic motivation of sharing power in design processes is that those who will ultimately use the product or service should have control over how it will impact their current practices and lives. This empowering, democratic rationale is at the heart of PD (Spinuzzi, 2005).

A precondition for sharing decision-making power is the establishment of mutual trust and respect between all the parties involved in the process (Bratteteig et al., 2013). This includes engagement towards one's own interests and the interests of the common good according to Kensing and Greenbaum (2013). To address the issue of power in design,

Bratteteig and Wagner rely on Braten's theory of Model Power (Braten, 1973 as cited in Bratteteig and Wagner, 2012). According to this theory, our models of the world and our ways of understanding constitute the basis for how we can utilize information, acquire knowledge and make decisions. The model in which information is interpreted or contextualized gives the originator of a model symbolic power, or, when the model is completely adopted by others, model monopoly. In the latter case, one model defines the universe of discourse and the scope of decision-making among individuals, whereby new information will only strengthen the position of the originator. This happens at the expense of the model-weak parties in the group, because they may not be able to utilize new information to the same extent. When one models defines the discussion, the relationship between the model-rich and the model-weak is asymmetrical and will continue to do so (Braten, 1973 as cited in Bratteteig and Wagner, 2012). For instance, when developers define a design problem in a top-down fashion based on their technical knowledge, it may become difficult for those without technical knowledge to genuinely participate in the design process.

To address model monopoly, PD takes use practices as a basis for design instead of researchers' or designers' preconceived ideas about users, and a broad variety of stakeholders is invited into the design process to expand the universe of discourse (Bratteteig et al., 2013). To expand users' and other participants' influence, a problem statement rather than a fixed goal or research question is used as a starting point for design. Relying on Schön, problem setting and problem solving are thereby regarded as intertwined and inseparable (Schön, 1983). This means that future users and other participants co-determine the agenda (what is being discussed) and the scope of the design process (which problems are defined and judged relevant), and envision and concretize ideas together. This process requires continual participation, revisiting earlier steps and sustained reflection (Spinuzzi, 2005).

1.3.2 Mutual learning

The second principle, mutual learning, refers to the learning process between users and designers. This learning is two-way in that designers learn about the use context from the users and users learn about technical possibilities from the designers. The basic idea is that no participant knows everything and that a process of mutual learning is necessary in order for participants to respect and recognize each other's expertise. This mutual learning process develops when users and designers jointly and creatively explore the design space (Bratteteig et al., 2013).

Users' knowledge, however, is often difficult to tease out because of its tacit nature. Tacit knowledge refers to the kind of knowledge that cannot readily be expressed in words (Polanyi, 1983 as cited in Sanders, 1999), but requires sustained and iterative reflection on the user's current practices and/or use of a designed artifact (Spinuzzi, 2005). For instance, the act of making artifacts (e.g. low-tech prototypes of envisioned technology) can enable participants to reflect upon and express their tacit, deeper levels of knowledge. Sanders, among others, argues that without the act of making and the use of concrete reference materials, these tacit and latent needs do not surface which limits the potential for mutual learning (Sanders, 2000, 1999).

For Robertson and Simonsen (2013), mutual learning is at the heart of PD, which they describe as: "A process of investigating, understanding, reflecting upon, establishing, developing, and supporting mutual learning between multiple participants in collective reflection-in-action. The participants typically undertake the two principal roles of users and designers where the designers strive to learn the realities of the users' situation while the users strive to articulate their desired aims and learn appropriate technological means to obtain them." (Robertson and Simonsen, 2013). Referring to Ehn (1993), with collective reflection-in-action Robertson and Simonsen (2013) mean that mutual learning does not develop as detached reflection but through practice, which simultaneously encompasses action and reflection (Ehn, 1993). Users and designers directly work together in order to find a common ground that encourages and enhances understanding between the different actors in the design process (Kensing and Greenbaum, 2013). Put differently, knowledge and ideas in PD develop continuously as a result of the inter-action between users, designers and the particular context in which they engage.

Kensing and Munk-Madsen have identified three knowledge domains that should be established in PD projects: current practices, technological options and practices with new technology (Kensing and Munk-Madsen, 1993). Current practices constitute the knowledge and experiences that users bring to the design process. Designers, on the other hand, have knowledge about technological options and have concrete experiences with some of these options. Practices with new technology are the result of a mutual learning process and refer to the ideas and visions for new practices and how technology can support these.

Within these three domains, knowledge must be developed on an abstract and a more concrete experiential level. The main rationale is that users find it often hard to express what they really want or need (Argyris and Schön, 1974 as cited in Bratteteig et al., 2013). Hence, designers cannot just provide an abstract overview of technological options, because concrete experiences are also required to envision new practices. The further in the process, the more concrete these new practices become, because ideas are being developed and concretized through, for instance, mock-ups and prototypes.
Similarly, Ehn (1989) has suggested that PD should attempt to steer a course between tradition or participants' tacit knowledge, and transcendence or researchers' more abstract, analytical knowledge. Participants in the design process should find a balance between these two types of knowledge (Ehn, 1989). This balancing act or tension between what is and what could be forms the dialectical foundation of design, and results in what Höök and

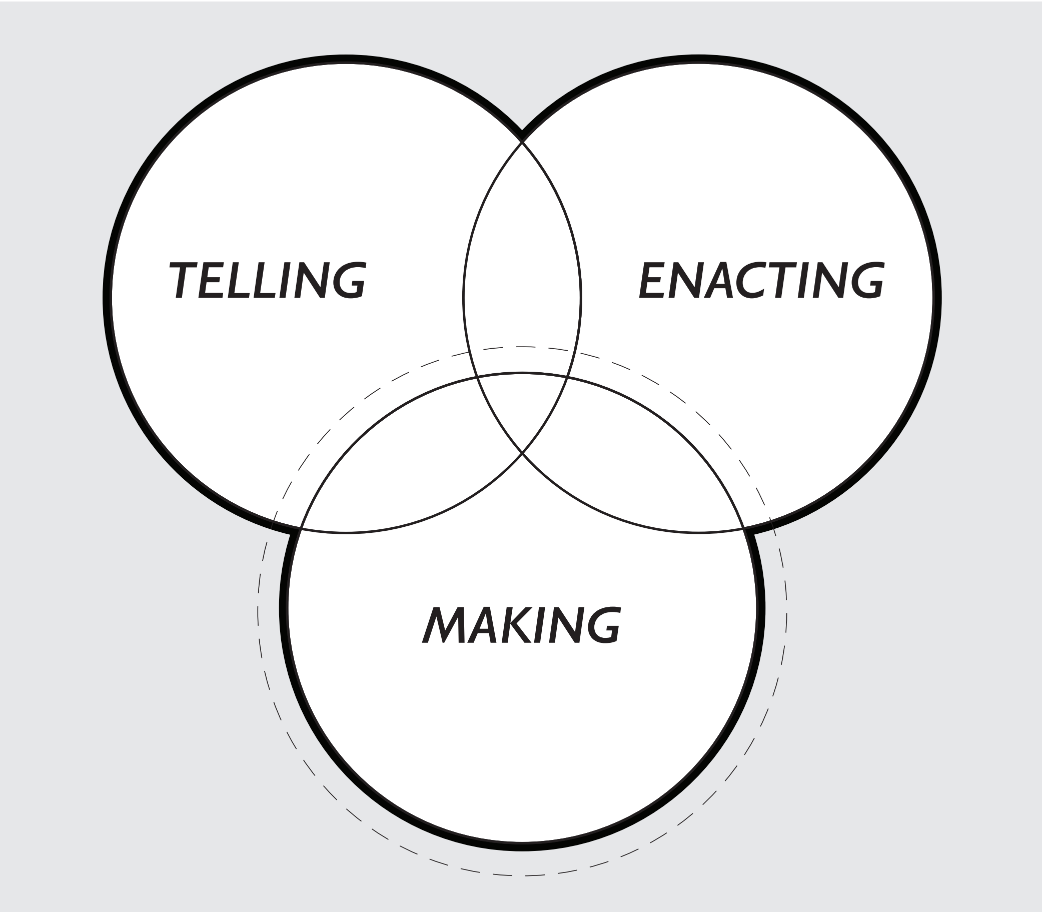

Figure 2: A coherent PD approach integrates methods, techniques and tools that focus on telling, making and enacting

colleagues have referred to as intermediate-level knowledge. This knowledge resides in the co-constructed artifact and is more abstracted than the concrete use practice that was used as a starting point for design, yet does not aspire to the generality of a theory (Höök et al., 2015; Höök and Löwgren, 2012).

1.3.3 Co-realization

The third and last principle, co-realization, relates to users having a say in the creation of the artifact. Together with designers, users and other participants take active part in visualizing and prototyping ideas and in learning about the qualities of the ideas in use or use-like settings (Bratteteig et al., 2013). This is a highly iterative process that re-quires continual participation, and sustained reflection on the designed artifact and the design process in general (Spinuzzi, 2005).

To this end, many tools and techniques have been developed over the past years, all with the same goal of enabling users and other participants in the design process to ex-press their needs and visions for the future in their own ways (Kensing and Greenbaum, 2013). By creating tangible artifacts (e.g. through generative techniques or prototyping), it becomes easier to understand the use context and the different technological possibilities, and to imagine the consequences of a design suggestion. This relates to Bratteteig's and Wagner's argument that, in order to avoid model monopoly and expand the universe of discourse, users should not be forced to adopt any abstract or formal language in order to participate in the design process (Bratteteig and Wagner, 2012). For instance, if users have to speak a technical, programming language to get their voices heard, they have to adopt the perspective or model within that language. This would limit their ability to express alternative visions about future technologies and practices, and hence would limit their decision-making power in design (Kensing and Greenbaum, 2013).

Co-realization in PD encompasses both action and reflection, but is also a social activity, because the making process takes place in cooperation with others (Ehn, 1993). Bringing together researchers, designers, future users and other participants, all with different backgrounds, competencies, experiences and interests is challenging. However, when all parties leave their familiar habitats behind and seek for a middle ground, something new can be formed (Brandt et al., 2013). Ideally, these making practices take place in a hybrid, third space that belongs neither to the domain of the users, nor to that of the designers and

Figure 3: A probes packet with four assignments, used to stimulate reflection and prepare children for a series of co-design activities

researchers. Relying on Bhabha, Muller describes PD as a border region between these two domains or spaces (Bhabha, 1994; Muller, 2002). This region of overlap and hybridity contains unpredictable and changing combinations of attributes of both domains. The practices that happen within this third space are uncertain and ambiguous in nature, but provide a fruitful ground for mutual or reciprocal learning between users and designers (Muller, 2002). This third space may literally be the space where a participatory workshop is organized, but it may as well be a social space encompassing the construction of a paper prototype. Whereas traditional approaches in the field of Human Computer Interaction (HCI) used to be one-directional (e.g. analyzing requirements from users or delivering a system to users), practices with-in this third space provide opportunities to learn something new that was not planned for (Muller, 2002). For instance, designers may find inspiration in how users envision future technologies and practices based on their personal experiences, and their tacit and deeper levels of knowledge that are revealed in the process.

To conclude with, co-realization in PD serves a dual purpose: understanding the contextual conditions for design and exploring opportunities for change. This is an iterative process in which research and design are intertwined and users are involved as active subjects with decision-making power. The mutual learning between designers and users throughout this process furthermore provides a basis for learning about one's own practices (Bratteteig et al., 2013).

1.4 Frameworks for participation

Despite PD's core principles having a say, mutual learning and co-realization, PD today is not one approach but a multitude of design practices that vary in attention to rigor and validity (Frauenberger et al., 2015; Spinuzzi, 2005), and rely on a varied set of methods, tools and techniques (Brandt et al., 2013). As a consequence, PD is often discussed as a research orientation or field in HCI, and not as a rigorous research methodology.

Some have argued that PD should be understood as a meta-method or methodology that aims to understand knowledge by doing, that is, the tacit and often invisible ways that people perform everyday activities and how these activities are shaped productively (Spinuzzi, 2005). As a methodology, PD relies heavily on Action Research, because PD practitioners conduct practical, interventionist investigations and parallel theoretical reflection instead of separating data collection and reflection (Ehn, 1993). The goal is not only to empirically understand the activity but also to simultaneously shape, envision and transcend it, or as Ehn put it "to steer a course between tradition and transcendence" (Ehn, 1989). This means that PD is as much about design as it is about re-search (Spinuzzi, 2005). The different research methods in PD are used iteratively to construct the design, which simultaneously constitutes and elicits the research results as co-interpreted by designers and users (Spinuzzi, 2005).

If PD is understood as a methodology, it is argued that it becomes easier to contribute to a coherent body of knowledge (Spinuzzi, 2005). Since PD's underpinning philosophy or paradigm is that of postmodernism, a constructivist notion of knowledge is adopted. Knowledge making is regarded as something that occurs through interaction among people, practices and artifacts; it is a condition of a certain context. To produce knowledge in PD, users and designers have to find a common language or mode of inter-action they both feel comfortable with. This view can also be found in the work of Frauenberger and colleagues who see knowledge production as a dialectic process mediated by values and strongly situated (Frauenberger et al., 2015).

This dialectic process is typically composed of three, iteratively applied phases: the initial exploration, the discovery process and the prototyping phase. For each of these phases, different methods can be used ranging from ethnographic methods during the exploratory phases to paper prototyping in the later design phases. Methods can be understood as prescriptions based on generalizations from a vast amount of empirically based experiences. Methods include a set of principles or recommendations, techniques for how to carry out specific activities, and tools or concrete instruments in support of these techniques (Bratteteig et al., 2013).

In PD, methods function as boundary objects that aim to establish common language games and coherence between the different social worlds of the participants. Muller has referred to this process as the enactment of a third space, that is, a border region be-tween the knowledge domains of researchers, designers and future users (Muller, 2002). Similarly, Ehn (1993) sees methods as scaffolds for a "temporary community of practice in the making". Practice entails both action and reflection, and is also a social activity produced in co-operation with others. These everyday practices of users are explored and put on stage in co-design dialogues, and in this coming together something new is formed (Ehn, 1993). Whereas PD can be understood as an overarching approach or methodology, co-design is one specific way to engage users as active participants by the act of making things, instead of treating them as passive research subjects.
Importantly, methods in PD should not be applied as single-method formulas, because that would be against the very nature of PD (Lee, 2014). The context in which these methods were initially developed and applied should be taken into consideration and, if necessary, adaptations are to be made. Sanders and Stappers use the term lived practices to refer to a method's roots and use practices (Sanders and Stappers, 2008). Methods in PD do not stand-alone and need to be accompanied with a participatory mindset (Sanders and Stappers, 2008), and with PD's core principles (having a say, mutual learning and co-realization) in mind (Bratteteig et al., 2013). In addition, to continue the sup-port for empowerment and participation of users and other participants, final results in PD practices are to be disseminated in ways that users can understand and share (Spinuzzi, 2005).

Over the years, different frameworks emerged to organize the proliferation of methods, techniques and tools in PD practices, and to help decide which approaches are best suited in which situations. Sanders and colleagues, for instance, presented a framework built around three dimensions: form, purpose and context (Sanders et al., 2010). Form describes the kind of action that is taking place between the participants (e.g. making, telling and/or enacting), purpose describes why the approach can be used (e.g. probing or priming participants, understanding participants' current experiences, generating ideas for the future), and context describes where and how the methods, techniques and tools are used (e.g. with regard to group size and composition, venue, relationships between participants).

Brandt and colleagues (2013), in turn, have distinguished methods, techniques and tools that focus on either telling, making and/or enacting (see Figure 2), arguing that a coherent PD practice entails all three types: "The successful participatory process is a community of practice in the making. Participants must be able to make things that give this practice a presence in the world. Similarly, the participatory practice must be told and enacted to become alive and generative also of that which is not yet experienced" (Brandt et al., 2013). In the following paragraphs we will discuss each of the three categories and focus in particularly on making practices, because they are the focal point in this PhD.

1.4.1 Telling

Telling activities aim to enhance and expand the dialogue of participation between designers, users and other participants and to bridge the gap between the different knowledge domains (Brandt et al., 2013). Linde (2001) for instance, has looked at the role of oral narratives in the expression and transmission of social knowledge at the workplace. These stories not only recount past events but at the same time convey the speaker's moral attitude towards these events. The stories are usually told within their specific community of practice, the workplace, and do not reach the communities of designers (Linde, 2001). Another example is provided by Dindler and colleagues (Dindler et al., 2005) who used a fictional narrative in a participatory setting to spur innovation. The fictional narrative was used as an overall frame for co-creation. The aim was to create a new universe where the normal structures of meaning and expectations were by-passed and, at the same time, a stage for action was set (Dindler et al., 2005).

1.4.2 Making

Making activities enable designers and users to externalize and embody thoughts, ideas and values by making things, and are most commonly associated with the term 'co-design'. It is believed that without these concrete reference materials, participants' tacit and deeper levels of knowledge would not surface that easily. The physical artifacts resulting from such making activities typically represent future technologies or provide views on future or envisioned practices. Brandt and colleagues distinguish three distinct approaches for making activities that are not mutually exclusive: probes, generative tools and prototyping (Brandt et al., 2013).

1. 4. 2. 1 Probes

Probes are delicately designed, playful instruments for data collection that invite ambiguous and emotional responses from users or other participants. A probes packet typically contains open-ended, provocative and oblique tasks, aesthetically visualized and aiming to support early participant engagement (see Figure 3). A key characteristic is the asynchronous nature: design researchers introduce a probes package but do not directly work on the assignments with the participants. Rather, they pick up and interpret the results after a few days or weeks. Probes, thus, is a design approach that invites people to reflect on and express their experiences, feelings and attitudes in their own time and environment, and in ways that are inspirational to designers (Gaver et al., 1999). Gaver, the originator of probes, puts it as follows: "The probes simultaneously make the strange familiar and the familiar strange, creating a kind of intimate distance that can be a fruitful standpoint for new design ideas" (Gaver et al., 2004).

More recently, Boehner and colleagues (2007) highlighted that the use of probes has become an umbrella term and that in some adaptations the experimental and subversive nature of the original probes is lost. A major focus of probes' uptake in HCI has used probes to develop objective, factual descriptions of user needs, while probes were originally designed to transgress the boundaries between research and design. Although this may increase the apparent generalizability, at the same time it reduces or eliminates the richness that probes can offer design. Probes were originally designed to spark inspiration, not to collect factual data, which entails a different epistemic grounding (Boehner et al., 2007).

1. 4. 2. 2 Generative tools

Generative tools provide yet another way to engage in making activities. These tools are commonly used at the early, fuzzy front end of design to collectively explore and express future ways of living or, put differently, to make sense of the future (e.g., Sanders and Stappers, 2008; Sleeswijk Visser et al., 2005). At the front end of design, also referred to as predesign, it is often unclear what the deliverable of the design process will be
(e.g. product, service, interface), hence the adjective fuzzy (Sanders and Stappers, 2008). In this phase, people's past, current and future experiences can be used to define a problem space and inform potential solutions (Sanders, 1999). The challenge is that, when non-designers are brought into co-design experiences at the fuzzy front end, they may feel that they are not creative or have insufficient knowledge (Sanders and Westerlund, 2011).

Generative tools were developed to overcome this challenge. These tools consist of 2D and 3D visual components that non-designers can use to express their feelings, ideas and dreams about future scenarios of use. Participants are guided in small steps to collectively construct designerly artifacts with these components. Afterwards participants tell a story about what they have made and why (Sleeswijk Visser et al., 2005). Just as probes, generative tools rely on ambiguity and evoke and provoke thoughts and feelings that participants do not commonly talk about. The main difference is that generative co-design techniques are used in a group setting and design researchers participate in these activities.

Sanders (2002, 1992; Sanders and Simons, 2009) who first introduced generative techniques, argues that the act of making enables participants to reflect upon and express deeper levels of knowledge that would not have surfaced without such concrete materials. With deeper levels of knowledge she refers to people's tacit and latent needs. Tacit needs are those needs that cannot readily be expressed in words (Polanyi, 1983 as cited in Sanders, 1999). To unravel these needs, designers need to understand what people feel and empathize with them. Latent needs are a particular kind of tacit needs that are usually unrecognizable until the future (Sanders, 1999).

Conventional user study techniques, such as interviews (what people say) and observations (what people do), are insufficient to bring these tacit and latent needs to the surface, because they are not projective and only reveal explicit knowledge (that what people are able to express in words) and observable knowledge (Sanders and William, 2001). Generative tools (what people make), on the other hand, are effective in accessing people's unspoken needs by revealing their thoughts, feelings and dreams (Sanders, 1999) (see figure 4). Sanders and Williams (2001): "Make methods enable creative expression by giving people ambiguous visual stimuli to work with. Being ambiguous, these stimuli can be interpreted in different ways, and can activate different memories and feelings in different people. The visual nature liberates people's creativity from the boundaries of what they can state in words. Together, the ambiguity and the visual nature of these tools allow people much room for creativity, both in expressing their cur-rent experiences and ideas and in generating new ideas.".

One of the theoretical foundations for generative tools is provided by Chomsky's theory of transformative generative grammar (Chomsky, 1965 as cited in Brandt et al, 2013). Generative grammars provide the possibility to create an infinite set of meaningful statements from a finite number of components. Similarly, generative tools provide a limited set of components that has the potential for an infinite variety of expressions about future practices (Brandt et al., 2013).

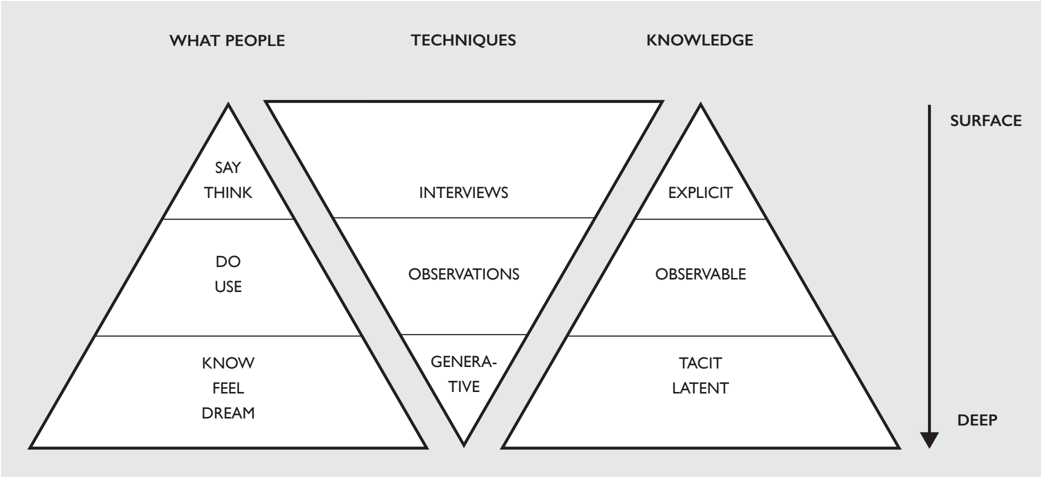

Figure 4: Sanders (1999) distinguishes between three types of knowledge about people; each type asks for different techniques in order to be revealed

Another foundation is provided by Koestler's theory of creativity (Koestler, 1964 in Brandt et al, 2013). According to Koestler, every creative act involves bisociation, that is, a process in which previously unrelated ideas are brought together and combined. Bisociation differs from association in that the latter refers to previously established connections among ideas and the former involves making entirely new connections. To make such connections, a person has to be thoroughly involved in a problem or situation for a prolonged time (Koestler, 1964). Hence, participants typically participate in more than one generative group session. In addition, probes packages are sometimes used as priming activities for this process of bisociation, and to individually prepare the participants (Sleeswijk Visser et al., 2005).

When using generative tools for making activities, the focus of analysis is usually on the story that comes along with the artifact rather than on the visual dimensions of the artifact. Indeed, in literature on how to analyze co-design artifacts at the early stages of design, the focus is typically on participants' verbal explanation as exemplified by the fol-lowing quote: "Every artifact tells a story and so we typically ask the creator of the artifact to tell us that story." (Sanders, 1999). For generative techniques, the making process and resulting artifact are just a means to an end: the verbal explanation of the artifact and the participants' deeper levels of knowledge embedded in that explanation. This is not to say that the visual dimensions of the artifact and their relation to the explanation are completely neglected, but the story is regarded as most insightful and useful for the design process (Sanders, 1999; Sleeswijk Visser et al., 2005; Stappers and Sanders, 2003).

1.4.2.3 Prototyping

A third type of making activities in PD falls under the term prototyping. A prototype is an early sample, model or release of a product built to act as a thing to be replicated and learned from (Nagel, 2001). A prototype is designed to test and try a new concept or process, and serves to provide specifications for a real, working system rather than a theoretical one (Nagel, 2001). Prototyping has a long history in PD, having been introduced in the early 1980s (Bødker et al., 1987). Making prototypes presupposes that you have already identified the object of the design. Thus, prototyping is used to create representations of future objects, that is, to help see what it could be (Brandt et al., 2013).

In this respect, prototyping differs from other making approaches such as generative techniques that are used at the early stages of design; prototyping is typically conducted at the middle and later stages. When prototyping is used as a co-design technique to involve multiple stakeholders, the focus is more likely to be on the artifact itself, rather than on participants' stories or verbal explanation of the prototype as in generative techniques (Brandt et al., 2013). This is not to say that prototyping is only useful for evaluative as opposed to generative purposes. Indeed, Floyd has distinguished three functions of prototypes: discovering desirable features (exploration), testing the adequacy of a proposed solution (experimentation) and changing a system gradually to changing requirements (evolution) (Floyd, 1984 as cited in Brandt et al, 2013). For each of these functions, prototyping has seen a wide uptake, also beyond the borders of PD in HCI more generally. Researchers in the UTOPIA project (Bødker et al., 1987) were one of the first to use mock-ups and other prototyping techniques to enable workers to actively participate in the design process (Ehn, 1993).

1.4.3 Enacting

When participants are engaged in enacting activities, they imagine and act out how their behavior might be affected by new technologies. They try things out in the context where the activities are likely to take place, or in settings that resemble this future con-text of use (Brandt et al., 2013). Enacting can be used to present a finished design but it can also be used as part of a work-in-progress in the early and middle stages of design. For instance, participants can enact a script that they made beforehand, but they can also rely on improvisation and experimentation. Thus, ideas and actions can be illustrated by the human body, but they can also emerge and develop through embodiment. En-acting possible futures is about setting in motion bodily, tacit knowledge, which, in turn, may evoke new and useful knowledge about what is to be designed (Brandt et al., 2013).

Enacting is closely related to scenario-based design. Scenario-based design is a family of techniques in which the use of a future system is concretely described at an early point in the design process (Carroll, 1999; Rosson and Carroll, 2002). Narrative descriptions of envisioned usage episodes are then employed in a variety of ways to guide the design process of the technology that will enable these use experiences. A big advantage of scenarios is that they are concrete and flexible at the same time, enhancing communication and rapid evolution of ideas. In addition, scenarios are evocative and help participants to reflect about their ideas in the context of doing design and not as detached reflection (Rosson and Carroll, 2002). Especially the combination of storytelling techniques and enacting activities (e.g. enacted scenarios) can be a powerful means to imagine and explore possible futures (Brandt et al., 2013).

1.4.4 Design games

It is often hard to draw a clear line between telling, making and enacting activities, as is the case for enacted scenarios and the use of fictional stories to frame co-design activities. Design games deliberately bring together all three types of activities. The basic idea is that design is modeled as a dialogical engagement with materials (Habraken and Gross, 1987 as cited in Brandt et all, 2013). This process is guided by a set of rules and taken forward through turn-taking among a number of game players.

Organizing PD activities that involve participants with different expertise, interests and professional languages is far from evident. However, through design games, power relations, and other factors that might hamper mutual learning and idea generation can be downplayed (Brandt and Messeter, 2004). Design games support participants in collaboratively exploring current and future practices and in deciding on the direction of the further design process. In a series of collaborative events, each organized in a game-like format, participants are engaged in telling, making and enacting activities. Key ingredients are the use of rules and tangible game pieces, which support different participants in making design moves (Brandt, 2006). The game materials, which are prepared by the design researchers, create a common ground that everybody can relate to. They become an inherent part of the common language and hereby the argumentation of the participants. Together with the use of game rules, game materials help to equalize participation, which leads to more constructive dialogues.

In that sense, game materials could also be seen as boundary objects (Star, 1989) that help to stage a third space in which participants with different backgrounds come together (Star, 1989). This coming together is not just an accumulation of insights or a negotiation of interests, but an explorative process in which potential goals and means are put into play and tested (i.e., a meeting of language games). The game elements make this explorative process engaging and fun, which fosters creativity. Moreover, the game part illustrates how participation is framed and negotiation between participants supported. This way, the concept of design games becomes an overall framework for participation in PD (Brandt, 2006).

1.5 Limitations and future directions for Participatory Design

1.5.1 Levels of influence

PD has sometimes been criticized that it does not lend itself to radical change because of its aim to ground changes in the knowledge and skills of future users, as well as other relevant participants as a way to empower them. Norman (2005), for instance, argues that too much attention for (future) users can lead to a lack of cohesion and overly complex designs (Norman, 2005). Although he considers listening to users a useful practice, an authoritative designer with a clear vision is sometimes needed to examine and evaluate users' suggestions for future technologies and practices. His main argument is that individuals are moving targets and, as a consequence, user preferences are hard to pin-point. In addition, taking suggestions of some individuals or groups into account may make things worse for others, because nowadays it is almost impossible to anticipate on all the different use contexts. Norman concludes that: "paradoxically, the best way to satisfy users is sometimes to ignore them" (Norman, 2005).

Other authors have raised similar concerns, arguing that radical change or revolution is sometimes needed instead of just incremental improvement or evolution (Beyer and Holzblatt, 1998). In addition to this risk for overly complex designs which lack innovation and a clear conceptual model, PD projects have been criticized for having only little impact outside the local context of the project, and that the initiative often dies when the project stops (Bratteteig et al., 2013).

These critiques may at least partly be due to practical limitations. Adopting a PD approach asks for an enormous amount of time, resources and institutional commitment. Whereas continuous participation and sharing decision-making power with future users and other relevant participants are at the heart of PD, these remain difficult issues (Bratteteig et al., 2013). In order for participants to take power and the responsibility that comes with it, mutual trust and respect between designers and participants are needed. Achieving this is often a time-consuming process that may slow down progression towards future technologies and practices. In addition, the required continuous participation of different stakeholders makes it difficult to determine the direction and structure of PD projects entirely upfront (Spinuzzi, 2005).

Despite these practical limitations, it is at least debatable whether PD projects only result in incremental improvements of current technologies and practices. Much depends on the particular project, its context and the PD approach. More research is needed on the relationships between making, telling and enacting activities, in order to better determine which approaches are most effective in what types of situations and for what types of participants (Brandt et al., 2013).

In addition, there is a need for solid approaches to ground PD projects as long-term strategies and on different societal levels (e.g. linking local initiatives to a larger context) to extend their influence (Bratteteig et al., 2013). As Iversen and Smith (2012) have argued, the end-goal of PD is not just the prototype resulting from a project, but to help participants realize that they do have a choice when it comes to the design of future technologies (Iversen and Smith, 2012). To this regard, others have called for the recognition that design is only completed in use, and that PD should explicitly support the potential for redesign for unanticipated use or change (Binder et al., 2011). This empowering dimension should not be backgrounded, which brings us to the next point: the mainstreaming of PD.

1.5.2 Pragmatic versus authentic approaches

Despite its foundational democratic motivation to empower future users in the design of technology, more recently PD has achieved a status as a useful commercial tool in some settings (Muller, 2002). Several major and influential consultancies formed their business identities around participatory methods. Their pragmatic approach to PD is concerned with developing better products by involving those designed for. Involving potential users is believed to provide better insights that would not have surfaced without user participation (Muller, 2002). PD is thereby reduced to a design method to optimize the outcome, that is, a user-friendly and desirable solution.

In this pragmatic notion of PD, designers do not fully share decision-making power, whereas the development of inclusive and democratic design solutions is the explicit goal of PD (Frauenberger et al., 2015; Robertson and Simonsen, 2013). Referring back to PD's core principles, the pragmatic PD tradition concentrates on setting up mutual learning processes while neglecting the political rationale to give future users and other relevant participants an actual say in the design process (Robertson and Simonsen, 2013). In addition, there is a tendency to focus too narrowly on artifacts rather than overall workflows and practices. In summary, we could say that in the pragmatic approach to PD functional instead of democratic empowerment is key (Spinuzzi, 2005).

As a response to this mainstreaming of PD, some authors have argued to rekindle values in what they call a more authentic approach to PD (Iversen et al., 2010; Iversen and Leong, 2012, 2012). In this view, user participation throughout the design process does not only make the product better, it is s an ideology. As such, it is not the use of participatory methods that makes particular work as being PD. Instead, it is about when, how and why these methods are used that renders the approach as being PD. For Iversen and colleagues, PD is about negotiating values realized through participation, and in respect to people's democratic rights. This ethos is based on the idea that the people whose activities and experiences will ultimately be affected by a design outcome should have a substantive say in what that outcome is (Iversen et al., 2010).

Despite these critiques on more pragmatic PD approaches, PD in all its forms contributed to the importance of user participation in HCI (Muller, 2002). Frauenberger and colleagues tried to reconcile both visions, arguing that the position on the spectrum from authentic to pragmatic does not matter that much, as long as the PD work exhibits qualities that are coherent (Frauenberger et al., 2015). This brings us to the problem of rigor in PD.

1.5.3 Scientific rigor

Being rooted in postmodernism (e.g. social constructivism, action research and phenomenology), a positivistic framework is rejected in PD because cognitive, rational approaches are found insufficient to take people's experiences and ideas into account. Knowledge is not seen as something that can be extracted from the individual, but rather as something that emerges in the interaction between individuals and their socio-cultural context, which transforms both (Hourcade, 2008). For that reason, PD adopted more holistic, interpretative and designerly approaches to make sense of how people experience the world and envision the future, each situated in their own environment (Kiskinen et al., 2003).

In line with action research, the PD practitioner thereby has a dual role: that of the traditional researcher collecting and analyzing data and that of the activist initiating significant change at the research site (Spinuzzi, 2005). Due to this delicate balancing act, ethnographic methods are often only loosely applied in PD compared to, for instance, trained ethnographers. As a consequence, PD practices have sometimes been criticized for being 'do-it-yourself ethnography' (Cooper et al., 1995; Forsythe, 1999). In addition, due to its differing epistemic grounds, PD has been judged to lack scientific rigor in a traditional, positivistic sense (Spinuzzi, 2005).

Rigor or "the quality of being valid" is concerned with the internal processes relating to decision-making and implementation in scientific research, and is commonly associated with deductive reasoning or measured evidence leading to universal truths (Frauenberger et al., 2015). However, the post-modern scientific paradigm on which PD builds does not allow for a similar degree of certainty or quantitative scaling, because the contextual interdependencies are too complex and the role of the researcher in the inquiry too important.
Nevertheless, it has been argued that scientific rigor is a desirable goal in PD practices. Höök and colleagues (2015), for instance, argued that PD practitioners should aim for rigor in how they do design rather than for their ways of thinking. In turn, Frauenberger and colleagues have proposed a more nuanced notion of rigor delivered through debate, critique and reflection (Frauenberger et al., 2015). To this end, they developed a tool-to-think-with that provides a common language for PD practitioners to have such debates by guiding them through a process of systematic reflection and critical analysis. Their tool proposes four lenses to critically reflect on the nature of the PD effort (epistemology, values, stakeholders and outcomes). In a subsequent step, the coherence between these different aspects is evaluated to see whether they pull the project in the same direction or work against each other. Regardless the position on the spectrum from pragmatic to authentic, it is the coherence of these different aspects that determines the level or rigor of PD work (Frauenberger et al., 2015).

1.6 Giving children a voice in technology design

A research area within the Human Computer Interaction (HCI) community that has concerned itself with how to best design and evaluate products with and for children is Child Computer Interaction (CCI). CCI investigates the phenomena surrounding the interaction between children and technologies, relying on inputs and perspectives from multiple scientific disciplines. The aim is to support an area of research and industrial practice that focuses on the design of interactive systems for children (Read and Markopoulos, 2013). Read and Bekker (2011) define the nature of CCI as "A study of the activities, behaviors, concerns and abilities of children as they interact with computer technologies, often with the intervention of others (mainly adults) in situations that they partially (but generally do not fully) control and regulate."

Although in recent years CCI has become a stable part of the HCI landscape, it is difficult to pinpoint when CCI began (Read et al., 2011). The first major works in the area include those by Papert (1980), Kafai (1995) and, subsequently, Druin and Solomon (1996) and Scaife and Rogers (1999). Since then, a large body of work has continued this journey designing and researching novel interaction technologies for children and developing suitable methodologies to involve children in the design process (Read et al., 2011). In accordance with the UN Convention on the Rights of the Child, children are defined as all persons aged less than 18. However, most CCI research targets younger children, peaking around 10-years-old (Yarosh et al., 2011).

A core value for the CCI community is to represent and respect the interests of children in the research and design processes (Read and Markopoulos, 2013). This recurring emphasis of having children participate in designing the technologies that they use, has its roots in constructivism. Characteristic for constructivism is the idea that children actively construct their own knowledge through experiences and that this construction is based on each child's idiosyncratic knowledge structures. This contrasts with the view that children can simply store knowledge imparted by others and that they all perceive and learn from an experience in the same way (Hourcade, 2008).

In addition, modern socio-cultural approaches such as Situated Learning Theory (e.g., Brown et al., 1989; Lave and Wenger, 1990) see knowledge as something that does not solely belong to the individual, because social interaction and collaboration are inherent components of learning. According to Situated Learning Theory, knowledge is being distributed between a network of individuals, tools and artifacts in a particular context. This community of practice embodies certain beliefs and behaviors that need to be acquired by the learner (Lave and Wenger, 1990). The interactions between the learner and the environment transform both (Hourcade, 2008).

Together, these theories and understandings have led to what Dawes calls a "reconceptualization of childhood" (Dawes, 2000). It is now widely recognized that children have their own child cultures and that power, status, social and economic differentials, resulting in a multiplicity of childhoods that need to be understood (Dawes, 2000). This has led to a critical examination of traditional methods, that positioned children rather passively in research. In child research through the 1990s, creative methodologies were being developed that drew on inventive and imaginative processes, such as in storytelling, drama and drawing. These techniques served as constructivist tools to assist children to describe and analyze their experiences and give meaning to them. Since then, participatory research with children has focused on the generation of knowledge through a merging of academic with local knowledge (Veale, 2005). Instead of merely extracting knowledge from children, the ways in which children engage in world making in their everyday lives is the focal point (Flick, 2009).

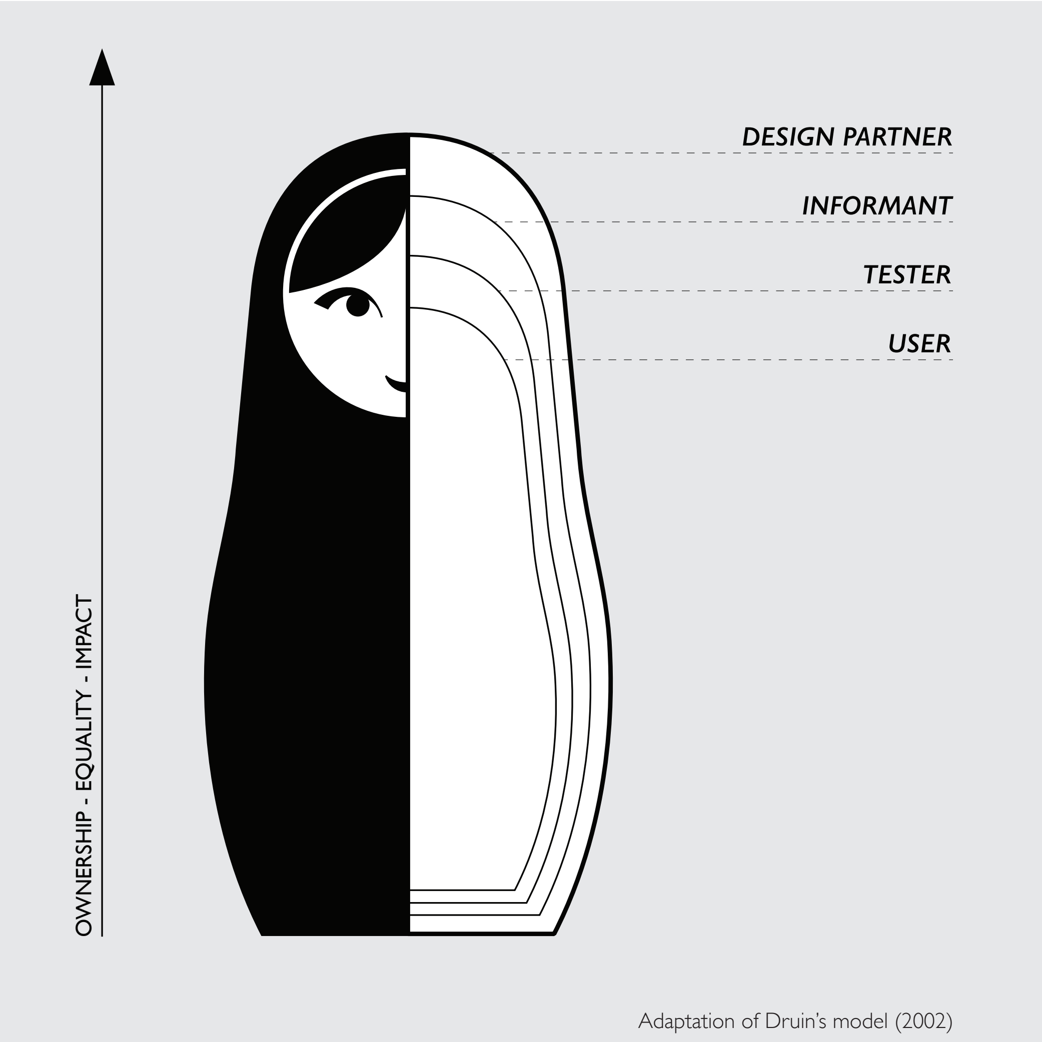

Figure 5: Children can take on four different roles in the design process according to Druin (2002), each with a different impact on the technology being developed

1.6.1 Informant Design

The same evolution could be witnessed in the CCI community. Initially, researchers sought for age appropriate evaluation methods to test working prototypes or existing technologies. As in HCI more broadly, these evaluation methods stemmed from cognitive theory and aimed to increase usability, productivity and control (Read et al., 2011). Involving children as testers assumes an asymmetrical relationship between children and designers, because designers have the sole responsibility and decision-making power to translate findings into suitable solutions. Under the influence of socio-technical and PD, children's role as passive users was gradually broadened to that of active participants (Read and Markopoulos, 2013). Scaife and colleagues were among the first to give children a more active role in the design process of technology for children (Scaife et al., 1997). They use a blend of low-tech prototyping techniques borrowed from PD to involve children as native informants at certain stages of the design process. Their aim is not to confirm what they thought they knew already (children as testers), but to discover something new (Scaife and Rogers, 1999). They do not treat children as equal partners, but rather hold a middle position between user-centered and PD. Their argument is that children are very good at letting designers and researchers know what keeps them engaged and motivated based on their experiences. On the other hand, children are not posited to, for instance, define their own learning goals in the design of educational technology. Here, input from educational specialists, psychologists and teachers is needed (Scaife et al., 1997). Designing technology for children is a balancing act between a number of different aspects such as learning goals, interface design, fun factor and technical feasibility (Scaife and Rogers, 1999). Scaife and colleagues (1997) therefore see different informants as shaping technology at different points in the design process. At early stages, children could be involved to help problematize the domain, in the middle stages to evaluate cognitive and design assumptions and in the final stages to evaluate prototypes in real-world contexts (Scaife et al., 1997).

1.6.2 Cooperative Inquiry

Other researchers who helped to broaden the role of children in the design process are Druin and colleagues (e.g., Druin, 2002, 1999; Druin et al., 2007; Guha et al., 2013), who consistently advocated equal partnership with children, which is a core tenet of Druin's Cooperative Inquiry method (1999). Instead of working with many different children over short periods of time, Druin aims for an on-going partnership with children throughout the entire design process. The goal of Cooperative Inquiry is to support intergenerational teams in developing new technologies for children with children or, as Druin (1999: 594) puts it, "to understand what children as technology users do now, what they might do tomorrow, and what they envision for their future". Instead of involving children at certain stages such as in Informant Design, Cooperative Inquiry offers a set of techniques borrowed from HCI research and PD to establish an intense involvement of and collaboration with children (Guha et al., 2013). The basic idea is that children can have a voice in the design of new technologies but that we need to better understand what it is that they have to offer.

Druin (2002) distinguishes four potential roles for children in the design process, each with a different impact on the technology being developed (see Figure 5). As users, children contribute to the research and development process by using technology while adults may observe, videotape or test for skills. Here, researchers try to understand the impact existing technologies have on child users to change or enhance future technologies. As testers, children evaluate prototypes of technology that have not been released to the market yet. Again, children are observed and/or asked for their direct comments concerning their experiences (e.g., Sim and Horton, 2012; Zaman and Vanden Abeele, 2010). The testing results are then used to change future iterations of the technology under development (Druin, 2002). When children take the role of informants, as we have seen in the work of Scaife and colleagues, they play a part in the design process at various stages, based on when researchers believe children can inform the design process (Scaife et al., 1997; Scaife and Rogers, 1999).
Finally, in the role of participants, children are considered to be equal stakeholders in the design of new technologies and they contribute in ways that are appropriate for children and the process (Druin, 2002). In this role, children have a more substantial role in defining the direction and the outcome of the design process, resulting in feelings of empowerment and achievement. Moreover, the participant role can also produce design-centered learning, that is, the kind of learning that can come out of design experiences. Another strength of design partnership is that researchers and designers do not have to wait, to find out what direction to pursue because they can collect instant feed-back from children at every moment in the design process. A challenge, however, is that neither adults nor children are in charge. As design partners they must work toward common goals and negotiate team decisions. This process of becoming used to design partnership takes time, both for children and adults, and asks for special techniques (Druin, 2002; Knudtzon et al., 2003).
Since Druin first introduced the approach, many techniques have been developed that fit under the umbrella of Cooperative Inquiry (Druin, 1999; Druin et al., 1998). These techniques all share the same goal, that is, to level power dynamics between children and adults, and to

support idea generation and elaboration. Bags of Stuff, for instance, is a technique whereby an intergenerational design team is divided in small groups to en-gage in low-tech prototyping activities (J. Yip et al., 2013). Once the low-tech prototypes are created, each group presents their ideas to the whole team and an adult takes notes on the big ideas on a white board. Big ideas are the ideas that are most surprising, most repeated among groups and evoke most reaction from the whole team (Guha et al., 2013; Knudtzon et al., 2003).
Another technique that is often used in Cooperative Inquiry studies is Layered Elaboration (Walsh et al., 2010). Groups are provided with a base design on which to elaborate and iterate without destroying the original or the work of other groups. This is achieved by adding a sheet of transparent paper after each group has added their ideas. Between iterations, stand-up meetings are hold to quickly explain the newly added ideas before handing the design over to another group for further elaboration (Walsh et al., 2010).
Mixing ideas is a technique developed by Guha and colleagues (Guha et al., 2005, 2004) to support younger children between the ages of 4 to 6 to more effectively collaborate. It entails a step-by-step procedure in which individual ideas are combined into one big plan. The technique helps children to see their influence on the final product, which, in turn, helps to build cohesion in the team (Guha et al., 2005, 2004). More recently, Walsh and colleagues (2012; 2015) developed an online environment called DisCo to support geographically distributed, intergenerational co-design. With this tool, children and adults can iterate, annotate and communicate ideas online and asynchronously, for in-stance, when they live in different countries or time zones (Walsh et al., 2012; Walsh and Foss, 2015).

1.6.3 Telling, making and enacting with children

The uptake of Informant Design and Cooperative Inquiry in the CCI community has led to a proliferation of techniques and tools to give children a voice in different application domains and use contexts. Different techniques that focus either on telling, making or enacting or a combination of all three can be distinguished, and will be discussed in the following paragraphs.

1.6.3.1 Telling

The use of narratives has been widely explored within the community. Dindler and colleagues developed a technique, Mission from Mars, to gather requirements among children by establishing a shared fictional narrative among the participants in the design process

(Dindler et al., 2005). It is argued that this shared narrative space motivates both children and designers in a playful manner. Moreover, it enables designers to ask sensitive or provocative questions that would not have been that easy to ask in a more conventional and less playful setting (Dindler et al., 2005). The Mission from Mars technique has been widely applied, such as by Verhaegh and colleagues who combined the technique with low-tech prototyping and evaluation techniques to inform the design of a mobile outdoor game for primary school children (Verhaegh et al., 2006).
A somewhat different use of narratives is provided by Duh and colleagues (Duh et al., 2010). Whereas the Mission from Mars method creates an overall narrative framework for the design activities, they propose a narrative-driven design approach. At the start of the design process, children are invited to create their own game narratives, which are used as a source of inspiration in the further design process. Children's terminology and conceptualizations are retained in the eventual game design, although designers can moderate children's inputs without infringing on them. This way, the tension between children's need to see their contributions and their lack of design or educational expertise can be managed. The ultimate goal is to make the games more relevant to children's life experiences on a contextual, temporal and cultural level (Duh et al., 2010).

1. 6. 3. 2 Making

Many techniques that have been developed in recent years fall under the umbrella term making activities. Some of these techniques fit within the Cooperative Inquiry approach and have been discussed in the previous section (e.g. Mixing Ideas, Distributed Co-design, Layered Elaboration, etc.). Here, we discuss other examples including the use of probes, generative techniques and prototyping.
To begin with, Iversen and Nielsen used digital cultural probes (i.e., mobile phones with camera and Dictaphone) to provide access to children's everyday lives, which are not easily accessible through conventional studies (Iversen and Nielsen, 2003). The probes results were used as a starting point for in-depth interviews. Together, the probes and the interviews, offered a rich collection of cultural material to inspire the further design process (Iversen and Nielsen, 2003). Another example is provided by Wyeth and Diercke (2006) who used probes in educational settings to gain contextual insight into the lives and learning practices of children.
Generative techniques, in turn, have been explored by Gielen (2008, 2007), among others, who developed an approach to facilitate children to dig into their latent needs and tacit

knowledge at the early, fuzzy front end of design. His approach provides rich in-sights into children's experiences and possible contexts of use, which are used to more accurately define the design problem and product category (Gielen, 2008). In addition, Sluis-Thiescheffer and colleagues (2007) experimented with brainstorming and prototyping techniques to generate as much ideas as possible at the beginning of the design process. They found that the design space is more fully explored and expanded when children are involved in low-tech prototyping activities than with more conventional brainstorming techniques (Sluis-Thiescheffer et al., 2007). Prototyping techniques have also been used by Baek and Lee (2003) who developed two prototyping toolkits, Info Block and Info Tree, to enable children to build information architectures for children's websites. These information architectures are believed to reflect children's cognitive characteristics and elicit their user needs (Baek and Lee, 2003).

1. 6. 3. 3 Enacting

Enacting techniques have also been explored in designing technology for children with children. Giaccardi and colleagues, for example, developed a performative co-design technique called Embodied Narratives (Giaccardi et al., 2012). It is an exploratory co-design technique for the early stages of design that stimulates dialogue and conversation through embodied interaction. Children make a storyboard and perform how they would use their proposed design. The performance is captured on video to share it with others as a way to support further exploration and ideation. The technique emphasizes the importance of embodiment by encouraging children to construct meaning through action (Giaccardi et al., 2012).

Somewhat similar, Hemmert and colleagues (2010) argue that embodied sketching techniques such as Bodystorming are more suitable for children than disembodied sketching techniques. In Bodystorming, children act out a scenario based on their imagination. They examine and concretize this scenario by role-playing and observation of the intuitive actions and reactions in which the body plays a major role. The results are then integrated into design concepts. According to the authors, embodied sketching techniques increase both the quality of the concepts and children's experiences as design partners (Hemmert et al., 2010).

1.6.3.4 Comprehensive approaches

Whereas the previously mentioned authors focused on one specific part of the design process and/or relied on a small subset of techniques, Moser (2012) combined different techniques into a unified approach to co-design games within the context of the school. Her Child-centered Game Development (CCGD) approach includes the use of probes, idea booklets, child personas, low-tech prototyping and guidelines for translating the results into game concepts (Moser, 2012). A similar meta-perspective can be found in the work of Mazzone and colleagues (2011) who developed a framework to support novice practitioners to prepare and conduct co-design sessions with children. They organized the complexity of co-design with children in five dimensions (who, where, what, when and how), describing the pros and cons of different techniques that could be used within each of these dimensions (Mazzone et al., 2011).

Similarly, Göttel (2013) developed a comprehensive approach in which children are provided with different entry and exit points to participate in the design process. In his proposed Avalanche Design Cycle (ADC), children start as testers of existing technology or working prototypes and once they are more experienced they can become inform-ants. As informants they discuss their ideas based on their experience as technology testers. Moreover, they are encouraged to comment on observations and possible implications of user tests conducted by their peers. After being engaged as informants for a certain amount of time, children are invited to become design partners by actively contributing to the development of new prototypes. Other children, who might have just joined the design team, consequently test these prototypes. Thus, instead of working with a fixed group of children over a prolonged period of time, new participants are constantly attracted and the design team renews itself over time. Importantly, children themselves choose when to enter or leave the design team, but always start in the role of technology tester. According to the author, a main advantage of ADC is that it allows for sustained team sizes and more representative groups, especially when applied in a school context (Göttel, 2013).

1.6.4 Rethinking children's role as design partner

Other researchers in the CCI community have tried to further broaden children's role as design partner, taking a more reflective stance on the meaning of participation. Garzotto (2008), for instance, proposes a more holistic perspective of children's relation to technology and investigated how their role in design can be broadened from technology to experience design partners. Whereas most studies focus on designing the digital artifact, Garzotto radically shifts the focus on how (existing) technology can be used or experienced in a specific context over a prolonged period of time. For example, in one of her projects, she involved children aged 10 to 11 as experience design partners to explore and co-design an effective workflow of educational activities with a given technology. This approach led to more reflective practices among children about the use of educational technology and resulted in creative uses beyond the expectations of the research team (Garzotto, 2008).

In turn, Van Doorn and colleagues have extended the role of children from that of design partners to co-researchers (2013). In a systematic approach, they prepare children to collaborate in setting up and conducting contextual user research and in analyzing the data. In their approach, children conduct interviews with other participants and in doing so increase their knowledge about people close to them, as well as about themselves. Based on these insights, children co-create personas to communicate their research results. In this role of researcher, children become sensitized about the design topic, because they discover similarities and differences between themselves and others. Thus, besides gathering more data, super-sources are created when involving children as researchers at the early stages of design (van Doorn et al., 2013). This idea to broaden children's role to that of researchers can also be found in the work of Yip and colleagues (2013) who gave children a leadership role in intergenerational design teams. They describe different case studies in which children led the design process, from initial problem formulation through different design iterations (Yip et al., 2013).

Finally, Iversen and Smith (2012) propose a values-led approach to partner with children in design. They distinguish between pragmatic PD approaches that focus on ad-dressing children's needs, interests and abilities (e.g. Cooperative Inquiry), and a more authentic approach to PD that goes beyond the design of the technological artifact. In practice, this means that they take a more profound interest in children's hopes, fears and dreams, and that children co-determine the direction of the design project. They argue that it is the responsibility of the design team to enable children to co-establish a problem space and participate fully in the design of technology the evaluation of the project. Thus, where Cooperative Inquiry and related approaches are brought to an end with the development of a final design outcome, their values-led PD approach invites children to continue the thoughts and discussions beyond the design process. The end-goal is not just the prototype resulting from a project, but to help children realize that they do have a choice when it comes to the design of future technologies (Iversen and Smith, 2012).

1.6.5 A wide variety of practices

In addition to the proliferation of telling, making and enacting techniques, and the more reflective stances about the meaning of children's participation and how it can be further broadened, a wide variety of PD practices emerged. Some CCI researchers moved into the wild leaving the safe environment of the lab, whereas others looked for ways to involve children with special needs, aiming for a more inclusive model of participation.

1.6.5.1 Moving into the wild

Whereas in Cooperative Inquiry a small group of highly motivated children is invited to a child-friendly lab at the University of Maryland (e.g., Druin, 1999; Guha et al., 2013) others have partnered with different types of children in more natural and real-life settings. A good example is provided by Horton and colleagues (2012) who developed a method, Mad Evaluation Session with Schoolchildren (MESS), for carrying out and arranging whole class design and evaluation sessions that are school friendly (Horton et al., 2012). Others have organized PD activities in museums to develop art education programs (Roussou et al., 2007), and to explore future exhibition spaces (Dindler et al., 2010). Additional examples are provided by Weiss and colleagues who conducted a three day design workshop with children in a shopping mall (Weiss et al., 2008), and by Kam and colleagues (2006) who used prototyping techniques to co-design technology with rural school children in underdeveloped regions in northern India.

The basic idea of working in situ is that it helps children and other participants to focus on the particular usage context, which stimulates creativity and idea generation for future technologies and practices. In addition, working with different types of children may lead to a more empathic understanding of children overall, because a wider range of interests and abilities are being accounted for in design. However, despite some of the examples mentioned above, there is a tendency in the CCI community to co-design technology with only a small number of highly motivated children.

1.6.5.2 Towards inclusive participation

In addition to extending the range of contexts, others have aimed for a more inclusionary model of participation by involving children with special needs or in sensitive settings, because these children are often left out in decision-making processes. Lindberg (2013), for instance, organized a series of design workshops to give children that were or had been treated for cancer a voice in the design process. One of her findings was that these terminally ill children should not be involved on a too personal level, because of the sensitivity of the topic. To create a sense of intimate distance, the children made fictional characters in pairs of two, and used these personas for further ideation in the next workshop (Lindberg, 2013). The same approach can be found in the work of Grundy and colleagues (2012) who used fictional characters as agents for co-designing technology in sensitive contexts. These fictional characters or cartoon personalities were created by children and used to facilitate communication (e.g. by referring to the character's behavior and personal qualities) without evoking emotional responses (Grundy et al., 2012).

As for children with special needs, Frauenberger and colleagues (2012a; 2011) involved both typically developing children and children with autism spectrum disorder (ASD) to create a technologically enhanced learning environment that scaffolds the development of children's social skills. The authors experimented with different sensory inputs and storytelling techniques to bridge tensions between system design and the imaginary worlds of young children (Frauenberger et al., 2012a, 2011). One of the main challenges they identified is that, just as with any other group of participants, children with disabilities cannot directly take on the role of designers and should not be expected to do so. This means that much of the input generated by (disabled) children requires interpretation and translation to become viable design (Frauenberger et al., 2012b).

Benton and colleagues (2012- also focused on designing assistive technology for children with ASD. They developed a method called IDEAS (Interface Design Experience for the Autistic Spectrum) to involve children with ASD in the technology design process, including a set of guidelines to deal with potential communication and collaboration difficulties. One such guideline is to use children's personal strengths to build up their confidence in the sessions. Another one is to ensure that children know what activities to expect during each session and to represent these in a visual way wherever possible (Benton et al., 2012).

In turn, Malinverni and colleagues (2014) focus on how to enhance the creative contributions of children with ASD. They discuss the empowering dimension of design activities, both in terms of the results and children's involvement, and offer a critical reflection on the delicate balance between structure and autonomy (Malinverni et al., 2014). Other examples are provided by Brederode and colleagues (2005) who brought together children with and without a physical or learning disability to co-design a mixed-reality game, and Garzotto and Gonella (2011) who involved non-disabled children as co-designers of supportive technology for their disabled schoolmates (Garzotto and Gonella, 2011).

1.6.6 Challenges and practical concerns

Developing new techniques to engage in telling, making and enacting activities with children has gained much attention in the CCI community over the past decade. Some of these researchers have concerned themselves with particular challenges that come with partnering with children in technology design. These include, among other things, interpreting children's input, and improving children's motivation and collaboration in PD practices.

1.6.6.1 Analyzing and interpreting children's contributions

A first challenge traces back to Scaife and colleagues' groundbreaking work in the late 90s (Scaife et al., 1997). They were among the first to give children a more active role in technology design, but, at the same time, acknowledged that this was not without difficulties. Children use different conceptual frameworks and terminology, which makes it difficult to understand the exact meaning behind what a child is trying to say. In addition, although children come up with many wonderful suggestions, their ideas are often unworkable in computing terms or may conflict with pedagogical goals (Scaife and Rogers, 1999). This problem of how to deal with children's input and how to balance the view of children with that of adults has been a topic of much debate since then.

Kelly and colleagues (2006), for instance, developed a method called Bluebells to balance child-centered design with expert design in a progressive approach that marries the best of both approaches. Children are involved as informants at certain stages with techniques such as I-Spy to gather contextual information and Hide and Seek to gather information about the content of an application or product. The iterations of inclusion and exclusion from the design activities gives the design team space to collate and examine the outputs and incorporate them into design documentation and produce initial prototypes. This way, the challenge of transforming design activities with children into something useful in a real world context is circumvented (Kelly et al., 2006). However, what remains unclear is how children's contributions were interpreted. The authors simply state that children's material had "great inspirational value" but this was not directly visible in the final design.
Frauenberger and colleagues, in turn, discussed how to manage the complexity of combining concepts and ideas that were generated through PD work with practical, technical, ethical and theoretical constraints (Frauenberger et al., 2012b). They found that a rational approach to produce a single solution does not work because of the wicked nature of design problems. To better understand the complexity of requirements, they re-lied on designerly

and speculative approaches to interpret children's input while remaining as faithful as possible to children's initial ideas. In making this process of interpretation more transparent, their aim is to increase internal rigor and accountability in PD with children (Frauenberger et al., 2015).

Another approach to better understand children's contributions has been proposed by Mazzone and colleagues (2008). Their goal is to go beyond an inspirational understanding of children's perceptions and interests by taking a quantitative approach to analyze children's qualitative contributions in brainstorming and low-tech prototyping activities. For instance, they thematically clustered and counted children's ideas resulting from a brainstorming exercise to reveal the number of ideas produced by each group for each category of contents (Mazzone et al., 2008).

Similarly, Read and colleagues (2014) have looked for better ways to include and represent children's ideas and to help children understand how their contributions are used in the further design process. Their TRAck (tracking, representing and acknowledging) method encourages careful scrutiny of children's designs, and allows researchers to distill useful design ideas in a quantitative manner. Researchers evaluate children's designs by identifying a predetermined number of "candidate ideas" per design and per team. Afterwards they make a final selection of "winning ideas" whereby each team is equally represented. With TRAck, a more inclusive PD process can be ensured, because the ideas that come through are those of the majority of children rather than those preferred by the designers (Read et al., 2014).

Despite these efforts, it remains challenging to deal with the multitude of ideas and suggestions produced by children, and to decide what is worthwhile and what is not (Bruckman and Bandlow, 2002). As for the approaches discussed above, broadly speaking, a distinction can be made between researchers looking for inspiration in the form of specific design ideas (e.g., Druin, 2002; Knudtzon et al., 2003; Guha et al, 2004; Mazonne et al, 2008; Walsh et al, 2010; Guha et al., 2013; Read et al, 2014;), and re-searchers who take a more interpretative stance by looking at the underlying rationale or deeper levels of knowledge embedded in children's contributions (e.g., Gielen 2007; 2008; Van Doorn et al, 2013; Iversen et al, 2010; Frauenberger et al, 2012). Especially within the latter category, the current literature on PD offers little guidance on how to analyze co-design outcomes in a transparent and systematic way.

Another tendency, which is to be found in both categories, is that most researchers focus primarily on what participants say about their creations, neglecting the visual and tangible dimensions of the produced artifacts (e.g., Sanders, 1999; Sleeswijk Visser et al., 2005). This focus on participants' verbal explanation assumes that co-design artifacts are regarded as a transparent means to access participants' perspectives. Buckingham (2009) has referred to this approach as naive empiricism, arguing that data from creative research cannot be taken at face value and needs to be analyzed with special attention for these visual dimensions. No method necessarily allows participants a direct or transparent means of expressing themselves or having their voices heard. He argues that, instead of falling back on verbal accounts or a descriptive analysis, methods are needed that can deal specifically with the visual and tangible dimensions of such mate-rials (Buckingham, 2009). To fill this gap, Brandt and colleagues have already called for more research on how to analyze data generated by making, telling and enacting activities, including co-design techniques (Brandt et al., 2013).

1. 6. 6. 2 Improving children's motivation and collaboration

Another challenge concerns how to better organize children's involvement and facilitate equal participation in PD practices, especially when working outside the lab, and with large and diverse groups of children. Whereas some researchers tried to address this challenge by focusing more broadly on how to enhance children's engagement and scaffold cooperation, others inquired into what drives and motivates children to participate in design processes.

Van Rijn and Stappers (2008), for instance, aimed to increase feelings of psychological ownership, which they see as a core motivation to participate in the design process. They revealed several signs that indicate ownership such as a willingness to contribute, the fact that children can and do take initiative, and children feeling proud and responsible for the results (van Rijn and Stappers, 2008). Somewhat similarly, Ho and col-leagues (2011) have looked at the role of empathy in collaborative design practices. They take a phenomenological perspective to analyze how different layers of empathy or embodied relationship influence participants' interactions and feelings towards each other (Ho et al., 2011).

Iversen and colleagues (2013), in turn, have looked at teenagers' motivation in PD. Relying on Cultural-Historical Activity Theory (CHAT) they distinguished between motivation and motives. Motivation is understood as the dynamic that characterizes a person's engagement in a particular situation, whereas motives are the goals that shape a per-son's engagement in particular activities over an extended period of time. The authors demonstrated how different tools that are often used in PD, both material and immaterial ones (e.g. rewards, storytelling, collaboration, endorsements, etc.), resonate with this theoretical understanding of motives and motivation. One of their main conclusions is that teenagers' engagement in

PD is highly dependent on how the tools are appropriated and valued in the relationships between the teenagers. The CHAT perspective provides a resource for understanding this process of appropriation in relation to teenagers' dominant motives and gives insight into how various tools can work together to support motivation in collaborative design activities (Iversen et al., 2013).
Despite these interesting approaches and findings, the question that remains is how children's motivation influences their engagement, and, in turn, how this affects group dynamic processes between children in PD practices. Especially when working in certain contexts, such as school, where not all children may be interested to participate.

Researchers in the CCI community only recently started to acknowledge the importance of group dynamics when involving children in design. For instance, Ho and colleagues (2011) argued that, especially in PD practices, teamwork is complex and asks for special consideration of group processes: "Without particular considerations attending team dynamics, all participating parties would be impeded from understanding their own duties as well as those of the others." Similarly, Vaajakallio and colleagues (2010) experienced difficulties with involving seven- to nine-year-olds as design partners at school: "They worked based on personal intuitions and interests rather than collaborating with team members." This is in line with Obrist and colleagues (2011) who experienced challenges in facilitating group dynamics between children in co-design activities, because most children were not yet accustomed to teamwork.
To better structure cooperation between children, Mazzone and colleagues (2010) have evaluated different techniques based on their capability to produce useful results and their suitability to engage and involve children as active participants. Their evaluation resulted in a set of recommendations for involving children in design such as using probes to get children started and involving a teacher or education expert before and during the sessions to assure the suitability of the design tasks (Mazzone et al., 2010).

In addition, Vaajakallio and colleagues (2010; 2009) have experimented with game-like design activities to enhance children's creative thinking and support dialogue. In previous studies they noticed that children find it often hard to translate their everyday experiences into useful design ideas. Although the game format somewhat supported the collaboration between children, new challenges emerged because the children did not understand all the instructions and the meaning of the game (Vaajakallio et al., 2010, 2009). They concluded that more active involvement of adults was needed to guide children's dialogues and

maintain focus on the design theme (Vaajakallio, 2009). The reason is that children have not yet built up a mature ability for constructive conversations and negotiations within a group, which are prerequisites for collaborative design activities (Vaajakallio et al., 2010).
Dodero and colleagues (2014a; 2014b) also relied on gamification techniques to co-design educational games with children in a school context, but combined these with techniques from Cooperative Learning. Their Gamified Co-design with Cooperative Learning (GaCoCo) approach wants to improve children's engagement and cooperation by making the design tasks more appealing to children with varying skill sets (Dodero et al., 2014a, 2014b). Sluis-Thiescheffer and colleagues (2007) also acknowledge that children have differing capabilities and interests. They relied on Gardner's (1983) Theory of Multiple Intelligences to compare early design methods. They found that a group of children comes up with a wider range of ideas when the design activity requires different, complementary intelligences (e.g. visuo-spatial, linguistic, musical, interpersonal, logical-mathematic, etc.) (Sluis-Thiescheffer et al., 2007).

Improving children's motivation and collaboration in PD practices remains a fertile area for further research. Of particular interest are the types of challenging group dynamics that may occur between children, and how these dynamics influence both process and results. Facilitating group dynamics is believed to have a positive impact on children's motivation as well as on the development of creative solutions (Cross, 1995), but the problem has not yet been thoroughly researched in the CCI community. If the problem is addressed at al, the majority of CCI-research focused primarily on remediating asymmetrical power relationships between adults and children, and neglected group dynamics between children (e.g., Druin, 2002; Guha et al., 2013; Mazzone et al., 2010).

1.7 Conclusion

In this chapter, we gave an overview of PD's history which originated in Scandinavia in the 70s and 80s, out of a democratic commitment to empower workers in an increasingly computerized work environment. Relying on Schuler and Namioka (1993), we described PD as an "approach towards computer system design in which the people destined to use the system play a critical role in designing it". Despite the lack of a strict definition or a set of rules, we highlighted three core principles, informed by PD's rich heritage and still relevant today: (1) the sharing of decision-making power with future users and other relevant participants, (2) the continuous process of reciprocal learning between all these participants, and (3) the

co-construction of future technologies and practices which simultaneously entails action and reflection (Bratteteig et al., 2013).
Notwithstanding these core principles, PD is not one approach but a multitude of design practices relying on diverse methods, techniques and tools that function as scaffolds for participation (Brandt et al., 2013) or what Ehn (1993) refers to as the "temporary community of practice in the making". In this chapter, we made a distinction between methods, techniques and tools that focus either on telling, making or enacting or a combination of all three (e.g. design games), and provided numerous examples. We furthermore discussed PD's limitations and directions for the future, such as the problem of scientific rigor, the mainstreaming of PD where functional rather than democratic empowerment is emphasized, and the risk for overly complex designs and a rather limited impact beyond the local context of a PD project.

In the second part of this chapter, we focused on partnering with children in technology design in order to represent and respect their interests and views for the future. Initially, researchers within the Child Computer Interaction (CCI) community sought for age appropriate evaluation methods, which involved children rather passively as testers of technology. Scaife and colleagues (1997) were among the first to give children a more active role in the design process with their Informant Design approach. Druin (1999) further broadened the role of children to that of equal partners, which is a core tenet of her Cooperative Inquiry method. The uptake of Informant Design and Cooperative Inquiry led to a proliferation of methods, techniques and tools to give children a voice in the design process. Again, we distinguished between telling, making and enacting approaches, and provided an overview of the research conducted so far in the field of CCI.
Next, we looked at the challenges that come with partnering with children, such as analyzing and interpreting children's contributions, and improving children's motivation and cooperation in PD practices. We gave an overview of the body of research that has concerned itself with these challenges and discussed areas for further research. Two challenges that have been insufficiently addressed in the CCI community will be the topic of this PhD research: (1) facilitating challenging group dynamics between children engaged in making activities in order to improve collaboration, and (2) interpreting children's contributions in a transparent and systematic way with the aim to move beyond a merely descriptive analysis and arrive at children's underlying values.

2. Methodology

2.1 Introduction

In this chapter we will discuss the research questions, the goal of this PhD research and the general approach, which is a combination of Research through Design (RtD) and case study research. Whereas the initial and rather broad goal of the PhD research was to look for (better) ways to give children a voice in the design of technology for children, the focus gradually shifted towards two specific challenges that are insufficiently addressed in the Child Computer Interaction (CCI) community: facilitating group dynamics between children in co-design activities, and the problem of analyzing co-design outcomes in a rigorous and coherent way.

In this thesis, Participatory Design (PD) is understood as an overarching design approach or methodology. Co-design, in turn, is used to refer to a specific way to collectively engage users and other relevant stakeholders as active participants in the design process through the act of making things. However, to render an approach as PD, the use of co-design techniques needs to go hand in hand with a process of reciprocal learning and the sharing of decision-making power between all relevant stakeholders, including design researchers and envisioned users.

2.2 Research questions and goals

2.2.1 Main research question

A core value for this PhD research is to represent and respect the interests of children in research and design processes. The underlying idea is that children actively construct their own knowledge through experiences, and that this construction is based on each child's idiosyncratic knowledge structures. Children do not simply store knowledge imparted by others, because they all perceive and learn from experiences in different ways. Therefore, in this research, the ways in which children engage in world making in their everyday lives is the focal point. Instead of merely extracting knowledge from children, we want to assist children to describe and analyze their experiences, and generate ideas for future technologies and practices.

Motivated by the belief that children should have a substantial say in the design of technology that will ultimately have an impact on their lives, the initial research question was as follows:

- RQ1: How and to what extent can we involve 9- to 10-year-olds in an appropriate and meaningful way in the early, fuzzy front end of children's technology design?

2.2.2 Sub-questions, research goals and envisioned impact

Based on first experiences with co-designing technology with children (see case 1 in chapter *6. A reflective account of four cases*, pp. 124) and an extensive literature review (see chapter *1. Participatory Design with children* pp. 25), we noticed that two aspects related to the main research question were insufficiently addressed in the CCI community:

- If at all, group dynamics between children during co-design activities are discussed rather superficially. The majority of CCI-research focuses primarily on remediating asymmetrical power relationships between adults and children, and neglects group dynamics between children themselves (e.g., Druin, 2002; Guha et al., 2013; Mazzone et al., 2010). However, facilitating group dynamics is believed to have a positive impact on participants' motivation and on the development of creative solutions (Cross, 1995). Since co-design is a group process and children aged 9 to 10 show an increasing need to conform to their peers, the issue of group dynamics becomes even more important. For more information, see section *1.6.6.2 Improving children's motivation and collaboration* (pp. 62) in chapter *1. Participatory Design with children.*
- Whereas some authors stick to a descriptive analysis of children's contributions in co-design (e.g., Mazonne et al, 2008; Read et al, 2014; Druin, 1999; Guha et al., 2013; Knudtzon et al., 2003), others take a more interpretative stance by looking at deeper levels of knowledge (e.g. tacit needs, values) embedded in co-design outcomes (e.g., Gielen 2007; 2008; Van Doorn et al, 2013; Iversen et al, 2010; Frauenberger et al, 2012). In this thesis, we focus on the latter strand, and aim for a further maturation of the interpretative co-design approach, addressing two aspects that have remained underdocumented in previous research: (1) a unilateral focus on the verbal explanation while neglecting the visual/tangible dimensions of co-design artifacts, and (2) a lack of transparency when interpreting children's contributions. Therefore, methods are needed to integrate the visual/tangible dimensions of co-design artifacts and their verbal explanations into a coherent and systematic analysis. For more information, see section *1.6.6.1 Analyzing and interpreting children's contributions* (pp. 60) in chapter 1. Participatory Design with children.

These problematic aspects of co-designing technology with children became the focus of our research, resulting in two sub-questions:

- RQ1a: How can we address challenging intra-group dynamics when co-designing technology with children since these dynamics affect both process (e.g. children's agency) and outcomes?
- RQ1b: How can we interpret co-design outcomes in a transparent and systematic way, incorporating both the visual/tangible and verbal dimensions and with the aim to identify children's underlying values?

To address these research questions we combined a research through design and case study research approach. Based on insights from multiple case studies and literature, this PhD research will offer:

- A reflexive account of multiple co-design studies with children, drawing on insights from literature (e.g. educational psychology, creativity theory, etc.), and resulting in a set of guidelines to co-design technology with children. For more information, see chapter *6. A reflective account of four cases* (pp. 124).
- A toolkit including a co-design procedure and a method to analyze co-design outcomes. The co-design procedure is especially useful to work with multiple groups of children synchronously at a high child-to-adult ratio (e.g. in a school context). For more information, see chapter *9. Co-design toolkit* (pp. 269).

In line with PD's core principles, the envisioned impact of the co-design toolkit is threefold:

- Having a say, also referred to as democratic empowerment: The co-design toolkit enables children to co-determine the direction and outcome of the design process at the early, fuzzy stages of design. These experiences may help children to become more aware of how technology impacts on their lives and environment, and that they can have a say in its design.
- Mutual learning, also referred to as functional empowerment: The goal of the co-design toolkit is to gain insight into children's ideas, viewpoints and underlying values, used to more accurately define the design problem. At the same time, children learn the creative mechanisms of design thinking and how to collaborate productively towards a shared goal with their peers.
- Co-realization: The co-design toolkit supports researchers in designing the process of participation at the early stages of design. By offering non-technical tools, children are enabled to reflect on their experiences and visualize and prototype ideas, and discuss these with their peers and researchers.

In what follows, we will first elaborate on the target group, and then we will discuss the Research through Design and case study research approach adopted in this PhD research.

2.3 Target group

The main reason why we target 9- to 10-year-olds is that children at this age are verbal and self-reflective enough to discuss what they are thinking, but, at the same time, their abstract thinking skills are only beginning to develop. This means that, when it comes to abstract concepts, they may still have a difficult time verbalizing their thoughts and much of what they say needs to be interpreted within the context of concrete experiences (Piaget, 1970).

According to Piaget (1970), 9- to 10-year-olds are still in the concrete operational stage (ages 7 to 11) of cognitive development, which means that they experience and understand the world fundamentally different than adults. Whereas children between ages 7 and 11 can think logically about concrete objects (e.g. they can add, subtract and categorize), they cannot yet think in hypothetical terms. Only when children enter the formal operational stage (ages 12 and up) their cognitive abilities become similar to that of adults, although their tastes and interests remain quite different (Bruckman and Bandlow, 2002; Piaget, 1970).

Following Piaget's classification, generative techniques such as co-design offer interesting opportunities to give children aged 9 to 10 a voice in the design process. Children at this age usually approach problem solving by concentrating on information that is immediately available through the senses. They solve problems one at a time within the empirical context of the problem, and they normally do not develop overarching theories (Hourcade, 2008). This aligns well with a typical co-design approach, in which children are engaged in making activities that stimulate ad hoc reflection and do not have to think about abstract issues without such concrete reference materials. Although Piaget's theory of cognitive development provided initial guidance for preparing co-design activities, it was not strictly applied. The reason is that, despite the theory's usefulness, contemporary research has shown that children may differ substantially from Piaget's prototypical description (Schneider, 1996).

Another reason why we chose this age group is the ongoing debate about how schools can foster the development of creativity and why that is important. Some have suggested that children's creativity continually increases, on average, just as any other cognitive development (Claxton et al., 2005; Lau and Cheung, 2010a), whereas others have shown that formal education is detrimental to children's creative abilities (Robinson, 2011; Torrance, 1968, 1967). Torrance (1968), for instance, suggests that children's creativity begins to decline around the age of six, reaching rock bottom in the fourth grade of elementary school.

Although heavily debated, this phenomenon is known as the fourth-grade slump in creativity and, according to Torrance, is caused by a need to conform to classroom expectations. The addition of peer pressure in the fourth grade results in an even greater need to conform, discouraging 9- to 10-year-olds to display creative abilities (Torrance, 1968).

Whether or not creativity develops in a linear fashion or with slumps and peaks, nowadays there seems to be agreement that education is only one possible factor, and that the developmental trend of creativity is caused by multiple factors including cognition, personality, motivation and the environment (Darvishi and Pakdaman, 2012) (for more information, see chapter *4. Design Thinking in co-design*, pp. 95). This is not to say that schools cannot do more to strengthen children's creativity, which is one of the main reasons why we choose to partner with children in a school context. By providing scaffolds for Design Thinking and setting up the right, collaborative atmosphere in co-design activities in school, children's creative abilities can be improved.

2.4 Research through Design approach

For this PhD research, we combined case study research with RtD. Bardzell and colleagues (2015) refer to RtD as "the practice of using Design Thinking, processes, and products as an inquiry methodology" (Bardzell et al., 2015). RtD does not only inform and inspire the design process, but also results in a particular contribution of knowledge. Through an active Design Thinking process (i.e., ideating, iterating and critiquing potential solutions), design researchers continually reframe the design problem as they attempt to make the right thing. The final output or knowledge production of this activity is a concrete problem framing and articulation of the preferred state, and a series of artifacts, prototypes, products and documentation of the design process (Zimmerman et al., 2007). This knowledge transcends the activity, is more abstracted than the particular instance (i.e., the specific situation for which a design was created), but does not aspire to the generality of a theory. This type of knowledge is referred to as intermediate-level knowledge (Höök et al., 2015; Höök and Löwgren, 2012).

In this research, we used a RtD approach to address two important challenges in co-design with children (RQ1a and RQ1b). Our research was explorative in nature and we did not aim for statistical generalization or theoretical replication. Instead, we adopted a more holistic, interpretative and designerly approach by offering a reflexive account of multiple case studies. The connection between the different cases can be compared with the different steps in a Design Thinking process: investigating multiple perspectives on a problem (grounding), generating different solutions (ideation) and refining the concepts with increasing fidelity (iteration). Here, the resulting artifacts or products are a procedure to co-design technology with children in a school context, an approach to analyze co-design outcomes (GLID-method), and an accompanying toolkit.

To document our process, we relied on Shön's (1983) notion of design as a reflective practice in which design researchers reflect back on the actions taken in order to improve their design methodology. Similarly, we documented each step and took our newly gained knowledge forward from one case to the next (see chapter *6. A reflective account of four cases* pp. 124 for a detailed description of this process). In what follows we will describe our case study research approach.

2.5 Case study research approach

According to Robson (2002), a case study research approach involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence. The central defining characteristic of case study research is the focus on a particular case (or a small set of cases) that is studied in-depth. Since the phenomenon under investigation and its context or setting are interwoven, both are studied in relation to each other. The unit of analysis or case can either be the situation, individual, group, organization or whatever it is that one is interested in (Robson, 2002).

In this research, four case studies were conducted, each involving multiple schools located in Flanders, Belgium. These schools were selected purposively, meaning that we did not seek a representative sample because statistical generalizability was not the goal. Instead, we selected information rich cases for in-depth study. For instance, we looked for schools in both urban and suburban regions, and aimed for a diverse mix of school systems (e.g. catholic versus state schools). This purposive selection of schools offered a varied mix of children, each with their own strengths and interests, compared to, for instance, a lab context (e.g., Druin, 2002; Guha et al., 2013). We argue that taking this wide variety of perspectives into account leads to a better understanding of children, especially compared to working with only a small number of highly motivated children.

2.5.1 Multiple-case embedded design

Four case studies were conducted that focused either on research question RQ1a or RQ1b, and involved multiple schools. Although single-case designs can be viable under certain conditions (e.g. rare or unique case, representative case, longitudinal case), the evidence of

multiple cases as in this research is considered more compelling and the overall study more robust (Herriott and Firestone, 1983). Similar to series of experiments, the replication logic underlying multiple-case designs is that each case either predicts similar results (i.e., literal replication) or contrasting results but for anticipated reasons (i.e., theoretical replication) (Yin, 2009). However, we did not apply a strict replication logic in this research, but rather took forward newly gained experiences and knowledge from one case to the next (cf. RtD approach).
For each of the single cases in this multiple-case design, the overarching research question was how to co-design technology with children in a school context. The first case in which three schools were involved was the most exploratory one because the sub-questions were not fully formed at that point. In the second case we focused more in-depth on the problem of challenging group dynamics between children (RQ1a) and, retrospectively, on the problem of analyzing co-design outcomes (RQ1b). The second sub-question was also addressed in the third case, and the first sub-question in the fourth case (see list of cases below).

Each of these four individual cases had a separate embedded case, being the particular design challenge that was different for each of the four main cases depending on the project. Yin (2009) distinguishes between holistic case designs that involve only one unit of analysis and embedded designs that involve one or several subunits of analysis. In a multiple-case study, each individual case may as well be holistic or embedded. In the latter case, the results of each subunit of analysis are not pooled across cases, but are part of the findings for each individual case. These individual cases are then compared in a cross-case analysis (Yin, 2009). Indeed, in this research, the embedded cases (i.e., the design challenges) are not to be confused with the overarching research questions (see section *2.2.2 Sub-questions, research goals and envisioned impact*, pp. 68) that link the different cases together into a multiple-case embedded design. The research design of this PhD research looks as follows:

First case

- Main unit of analysis: RQ1
- Design challenge: mobile learning application for children to learn about arts and culture
- Conducted in 2011 – 2012 as part of the ICIS project and in cooperation with Cultuurnet Vlaanderen (see: http://bit.ly/1UT9FDm)
- Three schools participated for a total of 103 children aged 9 to 10; five co-design sessions were organized per school for a total of 15 sessions

Second case

- Main unit of analysis: RQ1a and RQ1b
- Design challenge: digital tools to prevent (cyber-) bullying in primary school
- Conducted in 2012 – 2014 as part of the EMSOC project (see: http://emsoc.be)
- Two schools participated for a total of 49 children aged 9 to 10; two co-design sessions were organized per school for a total of 4 sessions

Third case

- Main unit of analysis: RQ1b
- Design challenge: increasing child-friendliness in Terms of Use of children's websites
- Conducted in 2014 as part of the EMSOC project and in cooperation with research group ICRI (KU Leuven) and Flemish broadcaster Ketnet (see: http://emsoc.be)
- 12 children aged 9 to 10 and one of their parents participated for a total of 24 participants; they were split up in two groups and each group attended one co-design session at the university.

Fourth case

- Main unit of analysis: RQ1a
- Design challenge: learning children how to sing and play music with mobile technology
- Conducted in 2014 as part of the MELODIA project and in cooperation with research group Social Spaces (LUCA) (see: http://bit.ly/1PrfdRO)
- One school participated for a total of 17 children aged 9 to 10; two co-design sessions were organized in the participating school

2.5.2 Research protocol

For each case, the same research protocol was followed. Two researchers were involved in each co-design session: one fly-on-the-wall observer focusing on children's behaviors and interactions, and one researcher who facilitated the co-design sessions. Sessions were recorded on video and the discussions at the end of each session were fully transcribed. Immediately after a co-design session ended, a report was written about the session based on the observation notes and the facilitator's experiences. Focus points in these reports were:

- The collaboration between children: how do they interact, make decisions together, deal with differing voices, motivate each other, etc.
- How do children approach the creative assignments: how are children's Design Thinking skills, do they understand how the different steps contribute to the final prototype, etc.
- The amount and type of adult facilitation that is needed, both for class management and content support: do children need help to get started, to manage disputes, etc.

All co-design outcomes, from the initial ideas on sticky notes to the eventual artifacts, were photographed and physically stored at the university. Video footage, photos and transcripts of the verbal presentations were anonymized and digitally saved. The observation notes, video footage and reports were analyzed to address the first research question (RQ1a) on challenging group dynamics. In addition, these data were used to contextualize the co-design artifacts and the transcripts of the verbal discussions, which were subject to the second research question (RQ1b) on how to analyze co-design outcomes. In what follows we will describe in more detail how we addressed both research questions.

2.5.2.1 RQ1a: Challenging group dynamics

The data of the first case (observation notes, video footage and reports) was coded bottom-up using an open and axial coding approach. While going through the data, we developed categories by looking at patterns in children's actions and behavior during co-design activities. These sensitizing concepts were still imprecise and relatively poorly defined. The goal here was to impose some kind of initial order to the data. By further playing with the data and making visual representations, we gradually addressed RQ1a more explicitly. The analysis eventually resulted in reflective descriptions of the most prevalent challenging team dynamics across the three participating schools.

To anticipate on these challenging dynamics and better structure collaboration between children, we relied on Social Interdependence Theory (SIT) for the second case. We modified our co-design procedure by applying the theory's mediating principles for effective collaboration (see chapter *5. Perspectives on collaboration*, pp. 108). Because group dynamics have an impact on children's creative abilities, we furthermore relied on a Design Thinking model proposed by Thoring and Müller (2011) (see chapter *4. Design Thinking in co-design*, pp. 95). Just as in case 1, we observed and reflected on children's behavior while applying the procedure in a new series of co-design sessions. The dynamics identified in the first case were used as a framework to make sense of the data. Thus, where our approach was mainly inductive during the first case, here we used a combination of inductive and deductive reasoning.

For the fourth case (the third case did not focus on RQ1a) we used a different approach to analyze the data, because we did not conduct the co-design sessions ourselves. Two researchers used our co-design procedure which we iteratively developed through cases 1 and 2, and reported on its use afterwards. In these reports, the researchers described children's collaborative and creative endeavors, focusing on the same topics as we had done in case 1 and 2 (see section *2.5.2 Research protocol*, pp. 74). These written reports were thematically coded to prepare a semi-structured interview with the researchers with the aim to evaluate the procedure's usefulness, and to modify it afterwards based on the researchers' feedback. One of the topics discussed during the interview was the prevalence of challenging group dynamics and how this problem was dealt with by the researchers.

In summary, research question RQ1a was addressed in cases 1, 2 and 3, and resulted in a co-design procedure (see Figure 6). The iterative development of the procedure is discussed in chapter *6. A reflective account of four cases* (pp. 124), and the procedure itself can be found in section *9.2 The CoDeT co-design procedure* (pp. 270) in chapter 9. Co-design Toolkit. As for publications dealing with RQ1a, we refer to Van Mechelen and colleagues (2015b, 2014a) in chapter *7. Publications research question RQ1a* (pp. 181).

2. 5. 2. 2 RQ1b: Analyzing co-design outcomes

For the second research question on how to analyze co-design outcomes in a transparent and systematic way, we first reviewed and experimented with existing approaches. For instance, in the first case we relied on the analysis procedure as described in the Context mapping procedure (see Sleeswijk Visser et al., 2005) and in the third case we used a template approach used in the EU Kids Online project (Donoso et al., 2014; Livingstone et al., 2011). Only afterwards we started to develop our own theoretically grounded approach based on Means-end Theory, a values-led approach to PD and a social semiotic approach to multimodality (for more information, see chapter *3. How values can serve technology design*, pp. 79). This was a highly iterative process, for which we retrospectively used the outcomes of the second case (i.e., the co-design artifacts and transcripts of the verbal presentations) as case material.

In summary, research question RQ1b was addressed in cases 1, 2 and 3 and resulted in a method to interpret co-design outcomes in a structured and rigorous way (see Figure 6). The development of the method is described in chapter *6. A reflective account of four cases* (pp. 124), whereas the method itself is presented in section *9.2 The CoDet co-design procedure* (pp. 270) in chapter *9. Co-design toolkit.* As for publications dealing with RQ1b, we refer to Van Mechelen and colleagues (2016) (in press), and Derboven and colleagues (Derboven et al., 2015) in chapter *8. Publications research question RQ1b* (pp. 227).

2.6 Conclusion

In this chapter, the research questions, goals and methods were discussed. The overall research theme centers on designing technology for children with children. Throughout the first case, this broad theme was divided in two specific research questions that were

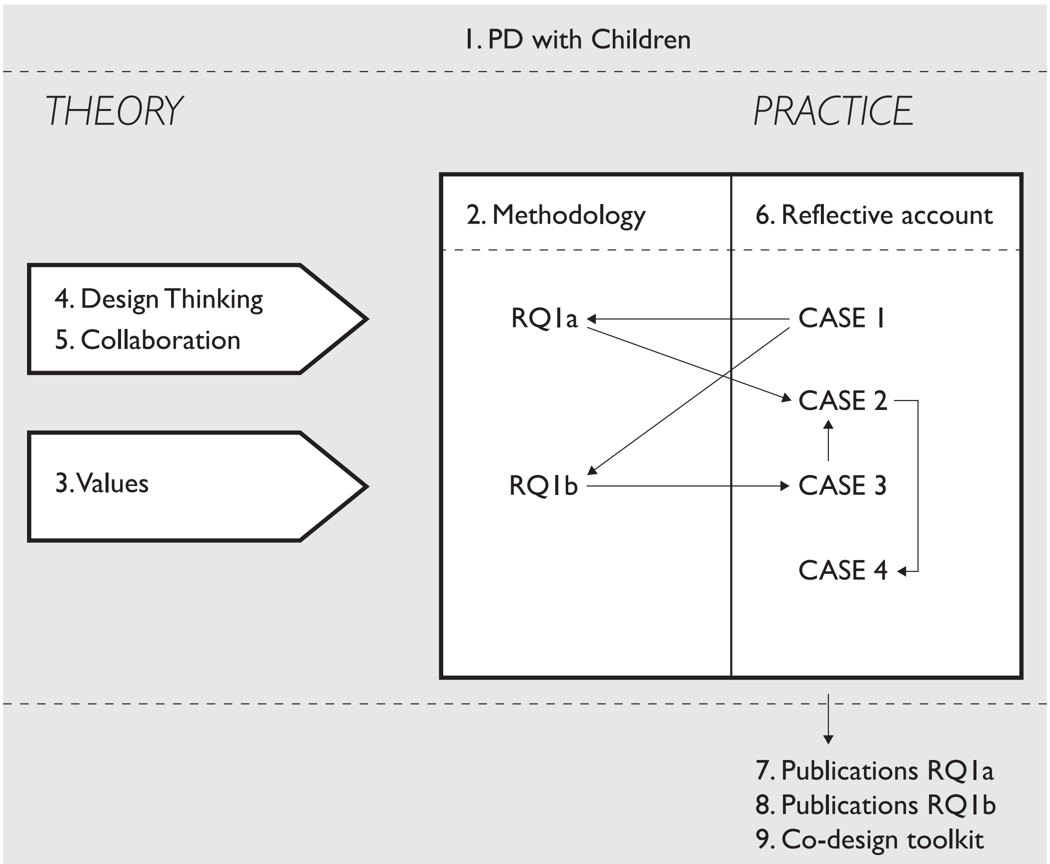

Figure 6: Blueprint of the PhD research, showing the interconnections between the different chapters, research questions, and cases

insufficiently addressed in the CCI community. The first question (RQ1a) focuses on how to address challenging group dynamics between children in co-design activities, which may hamper their collaborative and creative endeavors. The second research question (RQ1b) focuses on how to interpret co-design outcomes in a transparent and rigorous way, looking at both the tangible/visual dimensions of the artifacts and their verbal explanation. The aim is to move beyond a merely descriptive analysis and arrive at children's underlying values embedded in co-design outcomes.

To address these questions, we combined a Research through Design and Case Study research approach. The target group included children aged 9 to 10, and the focus was on co-designing technology in a school context at a rather high child-to-adult ratio (1 adult for ca. 15 to 20 children). Based on insights from literature (see chapter *3. How values can serve technology design* pp. 79 for RQ1b, and chapter *4. Design Thinking in co-design* pp. 95 and chapter *5. Perspectives on collaboration* pp. 108 for RQ1a) and multiple cases (see chapter *6. A reflective account of four cases* pp. 124), we developed a co-design toolkit in which both challenges are tackled (see chapter *9. Co-design toolkit* pp. 269). In the first part of the toolkit we present a co-design procedure to structure cooperation between children more efficiently (RQ1a), and in the second part we offer a method to deduce children's values embedded in co-design outcomes (RQ1b).

3. How values can serve technology design

3.1 Introduction

From its very beginnings, Participatory Design (PD) has been a highly values-led design approach that has concerned itself with the values of democracy, empowerment and empathy. These values are still deeply ingrained in many of the methods and techniques of PD. Moreover, in PD, knowledge generation is seen as a dialogic process that is strongly situated and mediated by participants' personal values (Frauenberger et al., 2015). At its core, PD practices are a negotiation of values that participants bring to the table or that emerge from the collaborative experience (Iversen et al., 2012, 2010; Iversen and Leong, 2012). Our work fits within this values-led PD approach. Therefore, in this section, we focus on how to move beyond a merely descriptive analysis of co-design outcomes in order to arrive at children's underlying values (cf. research question RQ1b).

First, we look into the multidimensional concept value by discussing widely used definitions and value classification systems. Afterwards, we discuss two distinct approaches in the field of Human Computer Interaction (HCI) that have concerned themselves with values: Value Sensitive Design and UX laddering. Both values-led design approaches and their theoretical groundings were used to develop a method to interpret co-design outcomes more rigorously and profoundly. With this method, children's values embedded in designerly artifacts as well as their verbal explanation are made explicit, and potential value conflicts between children and other stakeholders can be identified.

3.2 The multidimensional concept value

Value is a multidimensional concept that has been used in psychology and the social sciences to explain motivational bases of attitudes and behavior. Values help to govern people's behavior, and intermediate between the individual and the group. In some ways, values are universal in nature, illustrating similarities between societies, but in other cases, they are specific and illustrate the diversity of individuals and groups (Fleischmann, 2014).

A wide range of definitions has been developed over time. Parsons (1935: 306), for instance, defines a value as "the creative element in action in general, that element which is causally independent of the positivistic factors of heredity and environment". Rokeach (1973), in turn, considers values as the principles that guide people's behavior throughout life. Especially behavior that is related to maintaining and enhancing self-esteem is guided by values. Rokeach (1973: 23-24) defines values as "enduring prescriptive or proscriptive beliefs that a specific end state of existence or specific mode of conduct is preferred to an opposite or converse end state or mode of conduct". A differentiation is made between values that are modes of conduct (instrumental values) and values that are end-states of existence (terminal values). Terminal values are the goals that people want to achieve in their lives, that what they view as most desirable. Instrumental values are the preferred modes of behavior, the means to an end, and consist primarily of personal characteristics and personality traits (Rokeach, 1973).

Rokeach proposes a classification of 18 terminal values (e.g. equality, mature love, self-respect, wisdom) and 18 instrumental values (e.g. cheerfulness, self-control, honesty, obedience) that he beliefs are culturally shared. Although people's values come from culture,

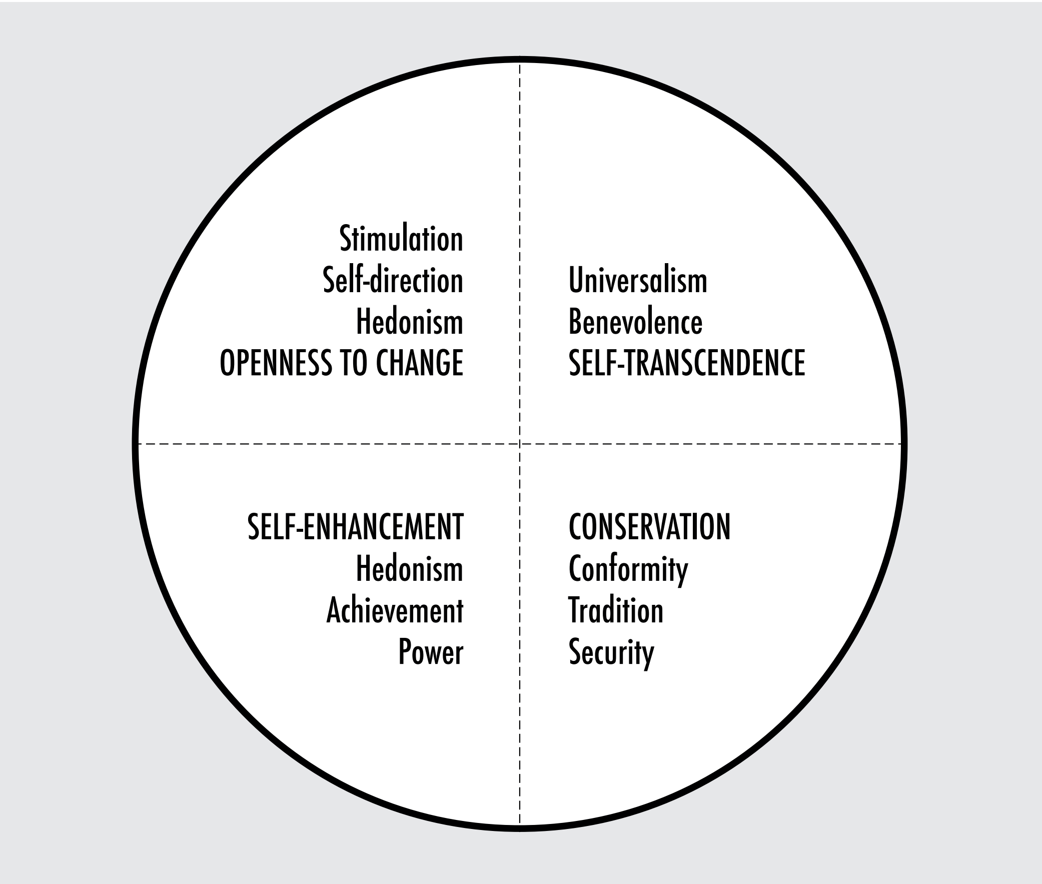

Figure 7: Schwartz' value classification system includes 10 basic personal values, divided in four opposing quadrants: openness to change, self-transcendence, self-enhancement and conservation

society and its institutions, individuals do not necessarily adopt the same values, and they may order values differently in importance with respect to one another. Moreover, whereas values are considered enduring and generally stable, individuals' value systems can change if they repeatedly make decision that involve putting one value ahead of another (Rokeach, 1973).

Schwartz (1992: 4) provides another definition that is widely used (see Figure 7). He defines values as "concepts or beliefs that pertain to desirable end states or behaviors, transcend specific situations, guide the selection or evaluation of behavior and events, and are ordered by relative importance". As in Rokeach's definition, values are considered critical motivators of people's attitudes and behavior. Schwartz identifies 10 basic personal values with different underlying goals or motivations, and subdivided by different, overlapping value items. For instance, the basic value hedonism consists of the value items pleasure, enjoying life and self-indulgence among others. These value items make the meaning of a value more specific and concrete (Schwartz, 1992).

In line with Rokeach, Schwartz (2012) stresses the cross-cultural recognition of his value classification system, but, at the same time, acknowledges that individuals and groups can have different value priorities or hierarchies. Besides these interpersonal or intergroup differences, an individual can also pursue competing values, be it through different acts at different times and settings. According to Schwartz, people's actions in pursuit of a particular value have practical, psychological and social consequences that conflict with some values but are congruent with others (Schwartz, 2012). For example, a parent valuing self-direction in education, characterized by the value items free exploration, creativity and choosing one's own goals, may perceive restricting children's internet access for protective reasons (security value) as psychologically dissonant.

According to Schwartz (2012), the tradeoff process between values is regulated by three principles. The first principle is the amount of congruence and conflict between the values that are implicated simultaneously in a decision. The total pattern of relations of conflict and congruity between values is portrayed as a circular structure divided in four quadrants: openness-to-change values (self-direction, stimulation, hedonism) are opposed to conservation values (conformity, tradition, security), and self-enhancement values (hedonism, achievement, power) are opposed to self-transcendence values (universalism, benevolence). Values in opposing quadrants are antagonistic in their underlying motivations, whereas values in neighboring quadrants have more similar motivations (Schwartz, 2012). A second principle that organizes the structure of values concerns the type of interest that the value attainment serves. The self-enhancement values power and achievement, and the openness to change values hedonism, stimulation and self-direction are related to personal interests and characteristics. In contrast, the self-transcendence values universalism and benevolence, as well as the conservation values security, conformity and tradition are related socially and affect the interests of others. Security and universalism are considered boundary values, because although they primarily concern others' interests, they also regulate the pursuit of own interests. Thus, whereas self-enhancement and openness to change values primarily regulate how one expresses personal interests and characteristics, self-transcendence and conservation values regulate how one relates socially to others (Schwartz, 2012). A third and final regulating principle is the relation of values to anxiety. The conservation values (conformity, tradition, security), and the self-enhancement values (power and achievement) are self-protective values that serve to cope with anxiety due to uncertainty in the social and physical world. Individuals who consider these values important seek to avoid conflict (conformity), try to maintain the current order (tradition and security) or attempt to actively control threat (power). In contrast, the openness to change values hedonism, stimulation and self-direction, and the self-transcendence values universalism and benevolence are self-expansive values that express anxiety-free motivations (Schwartz, 2012). Together, these three principles can help in predicting and understanding the relations between individuals' values to various attitudes and behavior. Not the absolute importance of any one value, but the relative importance or tradeoff between different values in a particular situation affects individuals' attitudes and behavior (Schwartz, 2012).

Schwartz' Value Theory has seen a wide uptake, although more definitions and value classifications exist. Cheng and Fleischmann (2010) did an extensive review of existing literature, resulting in the following definition of the concept of values: "Values serve as guiding principles of what people consider important in life." Values are distinguished from moralities, because morality involves doing the right thing and ensuring that everyone does the right thing. According to Fleischmann (2014), morality seeks to universalize but fails to take into account that individuals and groups do not necessarily agree on what the right thing is. To understand such disagreements, it is critical to highlight the underlying value conflicts that drive different but genuine positions on what the right thing is. These values do not reside in a vacuum but influence and are influenced by the context surrounding them. Like Rokeach and Schwartz, Fleischmann acknowledges that some values are culturally shared, but, at the same time, argues for a more situated understanding of values (Fleischmann, 2014).

3.3 Values in Human Computer Interaction

An increasing body of Human Computer Interaction (HCI) research has concerned itself with values and how they can be taken into account in the design and development of technology. This has led to a proliferation of understandings of the relation between values, technology and design, which, in turn, resulted in a variety of design approaches. Some have relied on existing value taxonomies to predefine values of importance for a given project (e.g., Friedman et al., 2006), whereas others adopted a bottom-up oriented approach to arrive at a more situated understanding of values (e.g., Halloran et al., 2009; Iversen et al., 2010; Le Dantec et al., 2009), or combined direct user input with value taxonomies to reflect on the data (e.g., Isomursu et al., 2011; Nouwen et al., 2015). In addition, Value-centred Design focuses on the development of the worthwhile, that is, "things that will be valued, as manifested in people's motivation, individually or collectively, to invest one or more of time, money, energy and commitment" (Cockton, 2006, 2005, 2004). Reflective Design, in turn, offers a set of design principles and strategies to question the values and dominant metaphors embodied in current technologies (Sengers et al., 2005).

What most of these approaches have in common is that they address technology design by what endures beyond interaction, i.e. the outcomes and lasting impacts, and not by the ease-of-use and contextual fit alone. Most values-led design approaches furthermore hold an interactional position on the relation between values and technology: they see values as neither inscribed into technology nor as simply transmitted by social forces, it works both ways. Since technology cannot be considered to be value-neutral, the underlying idea is that the values of those impacted by technology should be taken into account throughout the design process. This is also the case for two approaches that will be discussed in more detail in the next sections: Value Sensitive Design and UX Laddering.

Value Sensitive Design (VSD) is both a theory and method to design technology in line with ethical or human values (Friedman, 1996; Friedman et al., 2006). UX Laddering is an evaluation method that attempts to identify and understand the underlying values of preferred technology attributes (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010). Whereas VSD and the discourse surrounding the approach have been pivotal to broaden our view on how values can serve technology design, UX laddering and its theoretical foundation Means-end Theory have been useful to arrive at children's underlying values in co-design activities.

3.3.1 Value Sensitive Design

Value Sensitive Design (VSD) developed by Friedman (1997, 1996) is a theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner throughout the design process. VSD aims to offer an overarching theoretical and methodological framework with which to handle the value dimensions of technology design. The objective of VSD is not only to make the technology work in a functional sense, but also to make it sensitive to human or ethical values (Friedman, 1996).

3.3.1.1 Main characteristics

Friedman and colleagues (2006) rely on a rather broad definition of values as that what a person or a group of persons consider important in life. They reject the narrow meaning of the word value as the economic worth of an object. In their understanding, values should not be conflated with facts because facts do not logically entail value (cf. value/fact distinction). Values depend primarily on the interests and desires of human beings in their cultural milieu and, as a consequence, are subjective to the individual and group.

Although VSD recognizes that values can play out differently depending on the context, a position of cultural relativism is seen as problematic as well. According to cultural relativism, a person's values, attitudes and behavior can only be understood in terms of that individual's own culture. VSD rejects this notion and holds the psychological proposition that certain values are universal in nature, especially those with a higher degree of abstraction. To this regard, VSD suggests a list of 13 universal values of ethical importance that can guide any technology design process. The list includes human welfare, ownership and property, privacy, freedom from bias, universal usability, trust, autonomy, informed consent, accountability, courtesy, identity, calmness and environmental sustainability (Friedman et al., 2006).

Besides this focus on values of ethical importance, another characteristic of VSD is the interactional stance of the relationship between values and technology. Values are viewed neither as inscribed into technology (endogenous perspective), nor as simply transmitted by social forces (exogenous perspective). Whereas certain features or properties that are designed into technology may support certain values and hinder others, the actual use of the technology depends on the goals of the users interacting with it (Friedman et al., 2006). Moreover, through human interaction, technology itself is adjusted and changed over time. In sum, the interactional position holds that values are not solely designed into technology, nor do social drivers and forces solely convey them. It works in both directions (Manders-Huits, 2011).

Another feature of VSD is the thorough consideration of both direct and indirect stakeholders in the design of technology. Direct stakeholders are the people or parties who interact directly with the technology and its output, and indirect stakeholders are all other people or parties who are affected by the use of the technology. Within each of the two categories, there may be several subgroups and a single individual may be a member of more than one stakeholder group (Friedman et al., 2006).

3. 3. 1. 2 A tripartite methodology

VSD proposes a tripartite methodology to identify and implement stakeholder values in the design of technology, consisting of iteratively applied conceptual, empirical and technical investigations (Friedman, 1997, 1996). Conceptual investigations are theoretical and literature-based explorations to identify the direct and indirect stakeholders, the values at stake, and potential trade-off processes between competing values. Conceptual investigations result in careful conceptualizations of specific values that clarify the fundamental issues raised by the project at hand. In addition, these conceptualizations provide a basis for comparing and evaluating results in later stages of the design process (Friedman, 1996).

Conceptual investigations only provide a starting point and need to be informed by empirical investigations of the human context in which the technology is or will be situated. Empirical investigations are needed both in the generative design stages and to evaluate the success of a particular design. Since empirical investigations can be applied to any human activity that can be observed, measured or documented, a wide range of qualitative and quantitative techniques can be used. Whatever the technique, VSD suggests to use an indirect approach to identify stakeholder values and their implications, for instance, by asking people about a hypothetical situation or combining observations in a particular usage context with in-depth interviews. Once key values have been identified and carefully described, potential value conflicts can be identified. Importantly, value conflicts should not be considered as either/or situations in VSD, but as constraints on the design space. If the support of one value in a design directly hinders another value (e.g. trust versus security), a workable solution should be negotiated with the different stakeholder groups (Friedman, 1996).

Finally, technical investigations focus on the technology itself through careful analysis of how certain features support or undermine particular values. A given technology may be more suitable for activities in support of certain values, while rendering other activities and values more difficult to realize. Two types of technological investigations can be distinguished. In one form, they concentrate on how existing technologies or features and their underlying mechanisms support or hinder ethical values. In another form, these investigations involve the proactive design of technology that supports values identified in the conceptual and empirical investigations. Technological investigations differ from empirical investigations in their unit of analysis. Whereas the former focus on the technology itself, the latter focus on the different stakeholder groups that use or are affected by the technology (Friedman, 1996).

3. 3. 1. 3 Discourse surrounding Value Sensitive Design

As VSD matured over the years, it has been widely applied in many different contexts such as cookies and web browser design (Millett et al., 2001) augmented windows in future offices (Friedman et al., 2004), and homeless young people's experiences with information systems (Woelfer and Hendry, 2010). At the same time, a number of critiques and suggestions for further development have been published, which will be discussed below. Afterwards we elaborate on what we borrowed from VSD as well as the discourse surrounding the approach, and how this aligns with PD more generally.

VSD has been criticized for a number of reasons. First of all, VSD's notion of a universalism of values has been heavily debated (Halloran et al., 2009; JafariNaimi et al., 2015; Kujala and Väänänen-Vainio-Mattila, 2009; Le Dantec et al., 2009; Manders-Huits, 2011). It has been argued that VSD should put forward a more bottom-up and data-driven approach instead of relying on a descriptive definition of values of ethical importance (Halloran et al., 2009; Kujala and Väänänen-Vainio-Mattila, 2009; Le Dantec et al., 2009). In a direct critique on VSD, Le Dantec and colleagues (2009) argue that talking about values in an abstract way is of little use, because the visceral relationship to values as lived experience goes lost. The authors stress the importance of empirical investigations in order to build a situated understanding of values as "local phenomena expressed in a local vocabulary" (Le Dantec et al., 2009). In an answer to these critiques, Borning and Muller (2012) suggested that VSD should adopt a more pluralistic and perhaps even more humble position on this difficult and longstanding question of a universalism of values.

Another critique concerns the use of a predefined value heuristic in VSD. Some have argued that the list of 13 values of ethical importance used in VSD inquiries is only useful for evocative purposes (Kujala and Väänänen-Vainio-Mattila, 2009) or as a tool for reflection after local values have been identified (Le Dantec et al., 2009). Singling out certain values as particularly worthy of consideration raises ethical questions about who decides on these values and on what grounds. On the other hand, having heuristics and cues can help designers in considering the values that may be at stake in a given technology. A good example is provided by Isomursu and colleagues (2011) who first identified local values through a bottom-up process and then used Schwartz' value framework as an analytical tool. They argue that value heuristics are useful to interpret and discuss locally identified values, and that they enable research subjects to bring forward details that could otherwise not have been verbalized or observed, something they refer to as tacit knowledge about experienced value (Isomursu et al., 2011).

In any case, whether value heuristics are used to evoke values or to analyze and interpret findings from empirical investigations, there is the risk of confirmation bias and over-generalization. Therefore, it is suggested that value heuristics should be contextualized to increase transparency about who created the list and for what purpose (Borning and Muller, 2012).

Another point of critique is that it has become increasingly difficult to identify both direct and indirect stakeholders due to the proliferation of technologies and use domains (Manders-Huits, 2011). Even if this issue of identification is resolved, questions about how to reach stakeholders and how to make their values explicit remain largely unresolved (Kujala and Väänänen-Vainio-Mattila, 2009; Manders-Huits, 2011). Also, VSD is believed to provide only little guidance on how to deal with or prioritize conflicting values (Manders-Huits, 2011). In an answer to these critiques, Borning and Muller (2012) suggested that a distinction should be made between a project's given values, stakeholder values (including envisioned users) and researchers' personal values, to untangle this problem, because these values may differ considerably.

This problem of how to deal with conflicting values relates to another concern. Some authors stressed that VSD should adopt more participatory mindset by enabling users to speak for themselves and have an actual influence on the decision-making process (Halloran et al., 2009; Kujala and Väänänen-Vainio-Mattila, 2009). The authors argued that, in many VSD publications, the voice of the researchers dominates, both as interpreters and reporters of the results of empirical investigations. When researchers speak for informants to an audience, there is the risk of unintentional ventriloquism in which the researchers' own views are stated as if they were articulated by the informants (Muller, 1997).

Borning and Muller (2012) acknowledge this risk of ventriloquism, and suggest that it might be appropriate for VSD to commit to co-design and power sharing as seen in the PD tradition. In addition, they stress that the voice of the researchers should be made more explicit through the practice of self-disclosure, which includes providing information about one's background, personal values and the relation to the participants (Borning and Muller, 2012). This addresses earlier raised concerns about the lack of self-disclosure in VSD. The practice of self-disclosure is regarded as important because the interpretation of values is in itself value-loaded (Kujala and Väänänen-Vainio-Mattila, 2009) as is the decision about which values to take into account in the design process (Manders-Huits, 2011).

Another contested issue is that VSD does not reconsider values once they have been identified (Halloran et al., 2009; JafariNaimi et al., 2015; Manders-Huits, 2011). It has been argued that, despite their trans-situational nature, a person's value system or hierarchy might change and develop as the design process unfolds (Halloran et al., 2009). Some go even further, stating that values and design cannot be separated because they are intertwined in a dialect process of means and end (JafariNaimi et al., 2015). This implies that the situation for which a design solution is sought and the values that might serve that situation mutually influence each other as they develop together (JafariNaimi et al., 2015).
This contrasts with the typical identify/apply logic that is found in many VSD studies, in which values are first identified and conceptualized, and applied to design practice afterwards. In this logic, values are regarded as pre-established formula for proper courses of action, whereas values can only serve design as hypotheses. That is, to examine puzzling or indeterminate situations and possible actions that might transform these situations. JafariNaimi and colleagues (2015) argue that values cannot be applied to design practice, but can only serve as hypotheses to test conceptions of problematic situations and the action that they require in terms of a design solution. If a value hypothesis does not serve in the positive development of a situation, another hypothesis is looked for (JafariNaimi et al., 2015). This means that there is a high degree of uncertainty about which values might serve a situation and in what ways. It is suggested that VSD should embrace the idea that there is no single correct interpretation of values that serves all situations, because the same value can be appropriate in one context but problematic in another.
One way to provide a better, more situated understanding of values and how they can serve design (i.e., as hypotheses) is by involving users and other stakeholders in co-design activities. By collaboratively exploring the problematic situation, both the design problem and the values at stake develop, ultimately to be grounded in the co-constructed artifact (Iversen et al., 2012).

3. 3. 1. 4 Bridging Participatory Design and Value Sensitive Design

Despite the ongoing debates about how values can serve design, VSD has made a worthy contribution by putting the ethical dimension of technology on the agenda in HCI. By focusing on values of ethical importance, VSD has shifted the focus from the context of use to the context of impact. Similarly, PD is a highly values-led design approach, but instead of relying on a predefined set of universal values, knowledge generation in PD is seen as a dialogic process that is strongly situated and mediated by participants' personal values (Frauenberger et al., 2015). Notwithstanding this different perspective, both approaches are in many ways complementary (e.g., Davis, 2009). In our research, VSD and the discourse surrounding the approach have been useful for a number of reasons, all of which contributed to the development of a method to analyze co-design outcomes more rigorously and profoundly (cf. research question RQ1b).

The most obvious reason is VSD's focus on the value dimensions of technology design, thereby distinguishing between different stakeholder groups in order to identify potential value conflicts. Similarly, in the analysis of co-design outcomes, we aim to investigate how technology features and their underlying mechanisms might support or hinder certain activities and values. As in VSD, we prefer an indirect approach to identify stakeholder values and their implications, that is, through the use of generative techniques such as co-design. However, we do not necessarily aim for consensus, but rather want to highlight differences in value priorities between (groups of) stakeholders. Instead of relying on value heuristics as suggested in VSD, we prefer to explore local values by adopting a more pluralistic notion of values. In addition, rather than focusing on which values are considered important (cf. identify/apply logic), our goal is to gain insight in how certain values can serve, participate in and advance a problematic situation.

Another reason why we rely on VSD is the importance allocated to a thorough conceptualization of values through secondary research. However, following PD's core principles of sharing decision-making power and establishing a process of mutual learning, we prefer to put more emphasis on empirical investigations. Only afterwards, conceptual investigations can provide a framework for interpreting empirical data (e.g. co-design outcomes) more in-depth. In line with previous mentioned critiques, the bottom line is that we prefer a more substantial and active role for envisioned users and other stakeholders than suggested in VSD's tripartite methodology. For instance, by enabling children to voice their ideas and viewpoints in co-design activities. These activities merge empirical and technical investigations, because users and other stakeholders are engaged in the proactive design of technologies in support of their values.

In summary, what we borrowed from a values-led approach to PD and the discourse surrounding VSD is the idea is that co-design can be used to elicit values both on an individual and collective level. On an individual level, the act of making in co-design activities helps to raise awareness about one's own values and value trade-off processes. On a collective level, these personal values are then negotiated with other stakeholders, either implicitly or explicitly, which might in turn influence participants' personal value systems and reframe the design problem. We believe that children's co-designed artifacts and their explanations embody this negotiating and trade-off process.

3. 3. 2 UX Laddering and Means-end Theory

UX Laddering and its theoretical foundation Means-end Theory provide yet another foundation for addressing the second research question on analyzing children's contributions in co-design activities (cf. RQ1b). Whereas the discourse surrounding VSD expanded our notion of how values can serve technology design, UX Laddering offers a specific way to move from the surface or attribute level of children's ideas and suggestions to their underlying values.

3. 3. 2. 1 Relating product preferences to consequences and values

Vanden Abeele and Zaman (2011; 2010) developed UX laddering to study children's user experiences at the middle and later stages of technology design. The approach, that combines qualitative and quantitative research techniques, has its origin in consumer research and relies on Means-end Theory. According to Means-end Theory, people choose a product because it contains attributes (the means) that are instrumental to achieve desired consequences or benefits, which, in turn, fulfill certain values (the ends) (Gutman, 1982). Within its original setting, Means-end Theory aims at understanding consumers' personal motivations with regard to a given product or product class by focusing on the linkages between product attributes, consequences and personal values (Gutman, 1982; Reynolds and Gutman, 1988).
A central aspect of the theory is that values are a powerful driver of people's behavior. Following Rokeach's (1973) conception of values as preferred modes of conduct or end-states (see section *3.2 The multidimensional concept value*, pp. 79), it is suggested that values provide consequences with positive or negative valences. Since values are ordered in importance, they also give consequences importance, in that consequences leading to important values are more important to a person than those leading to less important values.

This interconnection between values and consequences forms the first linkage in the means-end model (Gutman, 1982). The second linkage is that between consequences and product attributes (e.g. certain functionalities). This means that, in order to make a choice between products, a consumer has to anticipate whether or not a product's attributes will produce a desired consequence in favor of a certain value (Gutman, 1982).

Although consumers' values influence their behavior, they are usually not aware of this process because it does not happen at the forefront of their consciousness. To force consumers to think in value-related terms about their product choices, Reynolds and Gutman (1988) developed the laddering procedure: an in-depth, one-on-one interviewing technique using a series of directed probes, typified by the "Why is that important to you?" question. By probing into the reasons why a product attribute (the means) is important for a respondent, the consequences and underlying values (the ends) can be identified. At the point where respondents can no longer answer the why question, the level of values is usually reached. The goal of the laddering procedure is to determine sets of linkages or ladders between the range of attributes, consequences and values, in order to provide insights into the motives for using a certain product (Reynolds and Gutman, 1988).

3. 3. 2. 2 Evaluating children's user experience

Vanden Abeele and Zaman (2011; 2010) relied on Means-end Theory and the Laddering procedure to evaluate children's user experience. Their UX Laddering technique aims to reveal why certain prototype features are preferred over others, and how these preferences relate to children's underlying values. Although Laddering was developed for consumer research, it is considered a useful technique for user experience evaluation because it corresponds well with current definitions of the concept user experience. The International Organization for Standardization, for instance, defines user experience as "a person's perceptions and responses resulting from the use or anticipated use of a product, system or service" (ISO, 2010). In line with this definition, UX Laddering addresses experiences as individually constructed and focuses on judgmental, evaluative responses (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010).

The UX Laddering approach as proposed by Vanden Abeele and Zaman consists of four steps and is based on a six-level means-end model (see Figure 8). Initially, the means-end model encompassed only three stages (i.e., attributes, consequences and values) (Gutman, 1982), but Olson and Reynolds (1983) extended it into a six-layer model that distinguishes between concrete and abstract attributes, functional and psychosocial consequences, and

instrumental and terminal values. This refined model was used to develop the UX laddering technique (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010).
Concrete attributes (CA) are the graspable, directly perceivable aspects of a product (e.g. color, material size). Abstract attributes (AA) are the intangible features that are not directly perceivable (e.g. styling or the level of convenience). Both types of attributes are invariant and independent on the judgment of the individual user (Reynolds and Gutman, 1988). Consequences, on the other hand, are directly tied towards the use and judgment and unfold in the interaction between a user and a product. Functional consequences (FC) are situated at usage level (e.g. an attribute that makes a player go faster in a game), whereas psychosocial consequences (PSC) exceed the usage levels (e.g. being immersed in a game, feeling better about yourself). Some consequences occur immediately when using a product (e.g. quenching of thirst), whereas others occur later (e.g. indigestion). Furthermore, some consequences come directly from the use of the product, whereas others occur in an indirect manner. For instance, having a new haircut makes you feel better (direct psychosocial consequence), and because you feel good, people react more favorable to you (indirect psychosocial consequence) (Reynolds and Gutman, 1988).

The next level, values, is characterized by the fact that users no longer mention the product and reach a level of abstraction by talking about the values, norms and moral beliefs they hold. A distinction is made between terminal values or preferred end-states of existence (e.g. happiness, security, achievement), and instrumental values or preferred modes of behavior to achieve these end-states (e.g. honest, broad-minded). Terminal values are intrinsically oriented, whereas instrumental values are extrinsic drivers (Reynolds and Gutman, 1988; Vanden Abeele et al., 2011). In the original means-end model, Gutman (1982) did not distinguish this intermediate step between consequences and terminal values. He argued that consequences are more akin to terminal values than to instrumental values in that a consequence is a state of being produced by an act of consumption. A consequence is not an end state, but its relation or ability to move a consumer toward an end state or terminal value is what gives the consequence its meaningful role in the model (Gutman, 1982).
Based on this six-level means-end model, Vanden Abeele and Zaman (2011; 2010) propose a four-step approach to evaluate the user experience of a prototype. The first step is the attribute elicitation phase whereby the interviewee is prompted to identify salient attributes of a prototype as explanatory for his or her preference. Next, the Laddering interview is conducted by probing into the reasons why these attributes are important. In the next step, the key elements are summarized by a standard content-analysis procedure, bearing in mind

CONCRETE ATTRIBUTE	ABSTRACT ATTRIBUTE	FUNCTIONAL CONSEQUENCE	PSYCHOSOCIAL CONSEQUENCE	INSTRUMENTAL VALUE	TERMINAL VALUE
Direct perceivable aspects of a product	Intangible features of a product	Immediate and tangible benefits achieved from experience with the product	Emotional benefits achieved from experience with the product	Preferred mode of conduct to achieve certain end-states	Preferred end-state of existence

Figure 8: A six-level means-end model as proposed by Olson and Reynolds (1983) and applied in the UX Laddering approach

the six levels of abstraction. Finally, all individual ladders are quantitatively analyzed, resulting in a summary table that represents the number of connections between the elements. The dominant linkages across the levels of abstraction are graphically represented in a tree diagram or Hierarchical Value Map. This overview provides insights into how children experience and evaluate a prototype, and how their preferences relate to their underlying values (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010).

UX Laddering has been widely applied in recent years to evaluate user experiences at the later stages of design, both in formative and summative settings (e.g., Celis et al., 2013; Saarinen et al., 2013; Vanden Abeele et al., 2012). Despite UX Laddering's evaluative purpose, the means-end model that forms the backbone of the method and the idea of a hierarchical value map provide interesting opportunities for generative research at the early stages of design, also known as the fuzzy-front-end. Making the linkages between attributes, perceived benefits and values explicit can be used in a similar fashion when analyzing co-design artifacts and their verbal explanations (cf. research question RQ1b). This does not only increase internal rigor and transparency, because the values can be traced back to the artifact's functionalities, but can also lead to a more situated understanding of these values.

3.4 Conclusion

Building on the theoretical insights in this chapter, and relying on Value-Sensitive Design, Means-end Theory and a values-led approach to Participatory Design, we developed a method (GLID) to analyze co-design outcomes in a transparent and systematic way, looking at both the visual/tangible and verbal dimensions of co-design outcomes and with the aim to better understand children's values (cf. RQ1b).

The method is based on the assumption that co-design techniques can be used to elicit values. On an individual level, the act of making in co-design activities helps to raise awareness about one's own values and value trade-off processes. On a collective level, these personal values are then negotiated with other participants, either implicitly or explicitly. This process reframes the design problem, and, in turn, influences participants' personal value systems. Ehn (1993) has referred to this process as 'collective reflection in action', which is at the heart of our values-led approach to PD.

We believe that the co-designed artifact and its verbal explanation embody this negotiating and trade-off process. However, to drill down to children's values a process of interpretation is required, for which we relied on the means-end model as applied in UX Laddering. The resulting method aims to arrive at a situated understanding of these values by interpreting the co-designed artifact and its verbal explanation in relation to each other and the context in which they were created.

For a description of how we iteratively developed the method, we refer to chapter *6. A reflective account of four cases* (pp. 124). The method itself is presented in Van Mechelen and colleagues (2016) and Derboven and colleagues (2015) in chapter *8. Publications research question RQ1b* (pp. 227), and in section *9.3 The GLID analysis method* (pp. 286) in chapter *9. Co-design toolkit.*

4. Design Thinking in co-design

4.1 Introduction

In Participatory Design (PD), various methods, tools and techniques are used as scaffolds for participation. Whereas PD can be understood as an overarching design approach or methodology, co-design is used to refer to a specific way to engage users and other relevant stakeholders as active participants in the design process. Through the collective act of making things, participants are enabled to externalize and embody their thoughts, ideas and values (Brandt et al., 2013). It is believed that without these concrete reference materials, participants' tacit and deeper levels of knowledge would not surface that easily.

For generative purposes at the early, fuzzy stages of design, co-design techniques are used to inform and inspire the exploration of open-ended design questions (Sanders and Stappers, 2008). The physical artifacts resulting from such making activities typically represent opportunities linked to future technologies or provide views on envisioned practices (Brandt et al., 2013).

4.2 Collective creativity

One of the underlying ideas of involving future users as co-designers is that everyone is creative. Most people, however, are not in the habit of using or expressing their creativity; their creativity is likely to be latent. Sanders and William (2001) argue that there is a wellspring of creativity that all people have when it comes to experiences that are meaningful to them, and that people are in a position to participate and generate ideas in the design process based on their knowledge and expertise (Sanders and William, 2001).

The same idea is reiterated by Alborzi and colleagues (2000) and Druin (2002), arguing that everybody has unique experiences and skills no matter what age or discipline. This notion that everyone can contribute to the design process can be traced back to Papenek's seminal book 'Design for the Real World' in which he states that: "All men are designers. All what we do, almost all the time, is design, for design is basic to all human activity. Any attempt to separate design, to make it a thing-by-itself, works counter to the fact that design is the primary underlying matrix of life" (Papanek, 1985: 3).

Another underlying idea of co-design, that can be understood as a form of collective creativity, is that making creativity more open and social through participatory processes will increase positive outcomes (Sanders and William, 2001; Sanders and Simons, 2009).

Participation of multiple actors in the design process is believed to promote discussions and expand the range of options (e.g. by consulting previous work, communicating with peers). In this situated view of creativity, the social and intellectual context is emphasized as a key part of the creative process (Shneiderman, 2000). Creativity is no longer seen as a lonely experience of wrestling with a problem, breaking through various blocks and finding clever solutions. Rather, creativity is embedded in a community of practice with changing standards and requiring a social process for approval (Schneiderman, 2000). This implies that, according to the cultural context, creativity and creative outcomes will be judged differently (Spendlove, 2005).

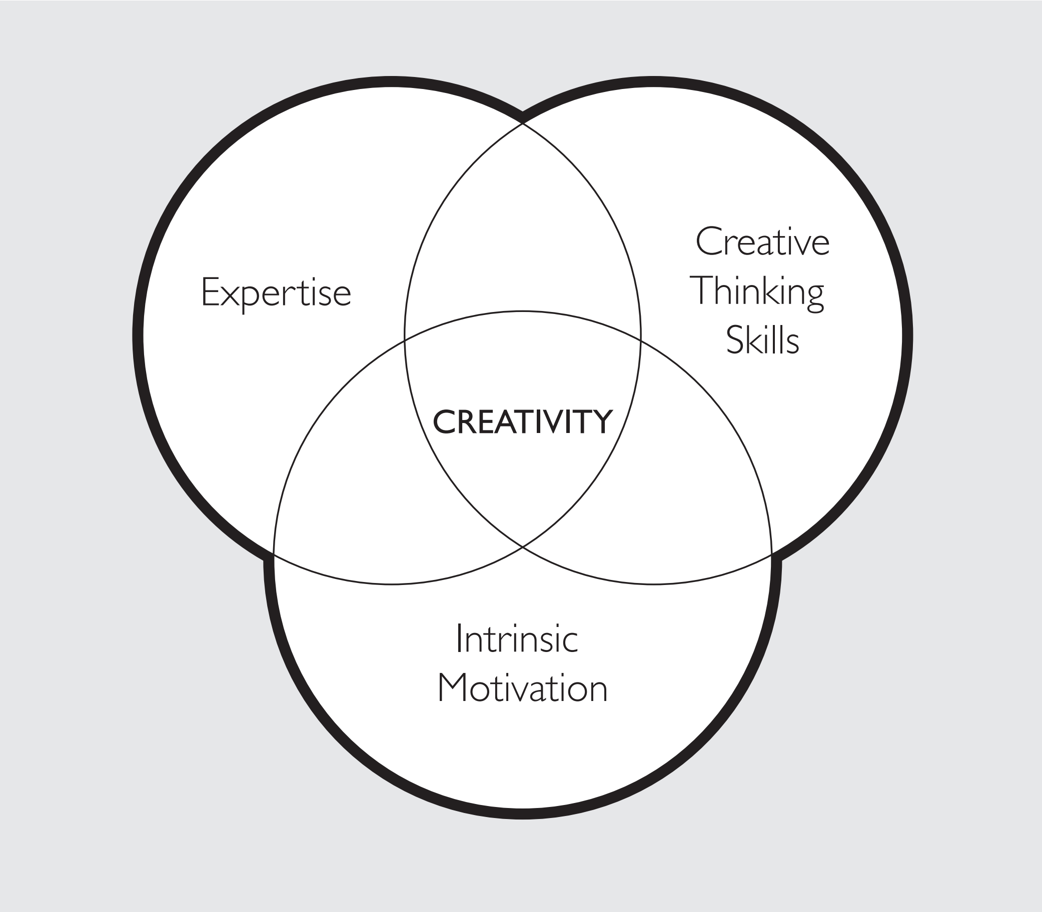

Figure 9: According to Amabile (1989) creativity is a function of three components: expertise, creative thinking skills and intrinsic motivation.

Both underlying assumptions that everyone can contribute creatively to the design process and that the socio-cultural context is an inherent part of the creative process, brings us to the questions what exactly is meant by creativity and how the creative process can be enhanced in co-design practices.

Often used is the definition of creativity as a process of creating something novel, valuable, useful and generative (e.g., Plucker et al., 2004; Stokes, 1999). Although in this definition the focus lies on the product or outcome, creativity can also refer to the creative process, the creative environment, and the creative person (Howard et al., 2008). With regard to the creative process, it is presently well recognized that creative thinking is an iterative process, successively running through several phases of preparation (when the problem is determined), incubation (when the unconscious mechanisms work through the problem), insight (when ideas of a solution are realized) and evaluation (when the ideas are elaborated, tested and assessed) (Kryssanov et al., 2001).

As for the creative person, creativity is often used as a synonym for divergent thinking or the ability to create different and various ideas for solving a single problem (Darvishi and Pakdaman, 2012). According to Guilford's model, divergent thinking can be divided into different cognitive components like fluency or the ability to create several ideas and solutions, flexibility or the capability of an individual to transfer from one group or category to another, originality or the ability to create new, unique and unusual ideas for solving a problem, and elaboration or the ability to further detail and add meaning to creative ideas (Guilford, 1959 as cited in Darvishi and Pakdaman, 2012).

In more recent years, the focus has shifted from cognitive aspects of divergent thinking to include how motivation and personality affect creativity (Claxton et al., 2005). Williams (1969), for instance, was among the first to suggest a cognitive-affective model of creativity that combined cognitive aspects of Guilford's model with affective processes. He argued that cognitive thinking processes of a creative individual cannot be separated from affective thinking processes (Williams, 1969).

In turn, Amabile (1998) has focused on motivational aspects of creativity, arguing that thinking imaginatively is only one part of creativity. According to Amabile, an individual's creativity is influenced by three aspects: expertise or domain knowledge, creative-thinking skills (e.g. persevering through a difficult problem) and intrinsic motivation (see figure 9). Whereas all three are important, in most cases it is easier to affect someone's intrinsic motivation than to try to influence someone's expertise or creative thinking skills. She argues that people will be most creative when they feel motivated primarily by the interests, satisfaction and challenge of the work itself and not by any external pressures. The right amount of challenge, supervisory encouragement and support, and sufficient workgroup features (e.g. enough diversity, willingness to support each other) are different but complementary means to influence people's intrinsic motivation and improve their creativity (Amabile, 1998).

4.3 Developmental trends in creativity

4.3.1 The fourth-grade slump

Because of the multifaceted nature of creativity, there has been considerable discussion about how creative abilities develop over the life span and how an individual's creative abilities can be measured. From a cognitive developmental perspective, children are supposed to show a subsequent increase in creative abilities as they develop and grow older because their social experience and education becomes broader (Lau and Cheung, 2010a). However, some researchers found discontinuity in the development of creativity with periods of increase and decrease over time.

Using measures of divergent thinking (i.e., fluency, flexibility, originality and elaboration) derived from Guilfords's (1959) work, Torrance (1968) was among the first to show that creativity begins to decline around age six, with the highest drop in creativity around the age of nine (Torrance, 1968). This process is reversed when children move into their teenage years, showing a subsequent increase in creative abilities (Torrance, 1968). This phenomenon became known as the fourth-grade slump in creativity was later confirmed in other studies (e.g., Amiri and Assadi, 2006; Lubart and Georgsdottir, 2004). According to Torrance (1967), and more recently Robinson (2011), the fourth-grade-slump is caused by the educational system that pays insufficient attention to imagination and creativity in the middle years of elementary school.

In addition to the need to conform to classroom expectations, Torrance suggested that the addition of peer pressure in the fourth grade results in an even greater need to conform, which discourages children to display creative abilities (Torrance, 1967). Whereas younger children are often more willing and likely to act out freely (e.g. to sing, draw, dance), older children may become more aware of their role in the group and how they expect that others might evaluate them (Torrance, 1967).

Others studies found no or only little evidence for a drop in children's divergent thinking scores around the age of nine, instead showing other patterns, such as an inverted U-shape pattern form ages 1 to 12 (Camp, 1994) and a J-shaped pattern from age 6 to 20 (Smolucha and Smolucha, 1985), or an overall trend towards an increase in creativity across primary and secondary school years (Claxton et al., 2005; Lau and Cheung, 2010a; Lopez et al., 1993).
Charles and Runco (2001), in turn, suggested that decreases in creativity appear at different ages and for various aspects of divergent thinking. In a cross-sectional study of third-, fourth-, and fifth-grade students they found that fourth-graders scored significantly higher in divergent thinking scores for the fluency factor (i.e., the ability to create several ideas and solutions) compared to third- and fifth-graders. They see creativity as just one facet of overall human cognitive development, which is not a linear process but develops in stages of peaks and slumps over time (Charles and Runco, 2001).

Following a meta-review of existing research, Lau and Chung Cheung (2010a) revealed that the majority of studies suggesting a fourth-grade-slump or a decrease in creativity include a relatively narrow age range, a small sample size and a lack of gender comparison in studying the developmental trend of creativity (Daugherty, 1993; Lau and Cheung, 2010a; Lubart and Lautrey, 1995; Torrance, 1968). On the other hand, studies that show an increase in creativity are typically large-scale studies with relatively broad age ranges.
In one of their own studies Lau and Chung Cheung (2010a) assessed 2476 Chinese children with an electronic version of the Wallach-Kogan Creativity Tests (WKCT: Wallach and Kogan, 1965). Just as the Torrance Tests of Creative Thinking (TTCT: Torrance, 1974), WKCT builds on Guilford's measures for divergent thinking. The test includes open-ended items that involve or depend upon free associations. Children respond to these items both verbally and figurally, and each answer is coded and scored for the criteria fluency (number of responses), flexibility (number of categories that could be formed from the responses), uniqueness and unusualness (relative frequency of a particular response) (Lau and Cheung, 2010b).
The authors found an increase in creativity from grade 4 to 5, a decrease from grade 5 to 6, a decrease from grade 6 to 7, and an increase from grade 7 to 9 (Lau and Chung Cheung, 2010a). Overall, they saw an increase in creativity during primary and secondary school years with the largest drop at grade 7, which corresponds with the school transition from primary to secondary school. They stress that small-scale studies are more likely to overlook this overall trend in the development of creativity (Lau and Cheung, 2010a).

4. 3. 2 Cognitive and non-cognitive aspects

Whereas the previous mentioned studies focused exclusively on cognitive aspects, others have included non-cognitive aspects in the psychometric analysis of creativity. For instance, in a longitudinal study in which 184 children participated from grade four to nine, Claxton and colleagues (2005) measured how affect relates to the cognitive aspect of creativity. They used the CAP test developed by Williams (1993) to measure both divergent thinking and divergent feeling (Williams, 1993 as cited in Claxton et al, 2005). The total score for divergent thinking, the cognitive component of creativity, was comprised of five factor scores: fluency, flexibility, originality, elaboration and title. The total score for divergent feeling, the affective component of creativity, was obtained by adding up four factor scores: curiosity, complexity, imagination and risk taking. To obtain the divergent thinking scores children had to complete 12 unfinished pictures within a time frame, and for the divergent feeling scores they had to respond to 50 statements with a Likert-type scale (Claxton et al., 2005).

Claxton and colleagues (2005) also could not find evidence for the fourth-grade slump or an overall decrease in creativity in the primary school years. The results of their study show that divergent thinking and feeling scores increase over time. However, divergent thinking scores reflect only a slight increase between the fourth and ninth grade. The only significant changes were found in a decrease in originality scores between the fourth and sixth grades, and an increase in elaboration scores between the sixth and ninth grade. Interestingly, they found a significant increase in all four factors of divergent feeling between the sixth- and ninth-grade scores when children enter early adolescence (Claxton et al., 2005). In other words, their longitudinal study seems to support the idea that, just as personality, creativity may still be developing when children enter adolescence.

Claxton and colleagues rely on Piaget's (1970) concept of cognitive development to explain the increase in divergent feeling scores and in creativity in general. Through the fourth grade, children tend to be concrete thinkers, meaning that their abstract thinking skills are only beginning to develop. As they grow older, children's ability to synthesize knowledge, and to assimilate previous events to personal thoughts and feelings expands, which allows children to better express their likes and dislikes (Piaget, 1970). This ability to think abstractly combined with the increased ability of self-expression may help explain why divergent feeling scores increase between grades six and nine. Around that time, children develop their own identity, and although they might be sensitive to peer pressure, internally they are developing their own personal thoughts and ideas about themselves and the world (Erikson, 1963 as cited in Claxton et al, 2005).

Cropley (2003) refers to these changes as the non-cognitive facets of creativity and suggests that the divergent feeling scores of the CAP test (Williams, 1993) relate to the motivational aspect of creativity along with personality characteristics (e.g. increase in self-awareness and identity) (Cropley, 2003 as cited in Claxton et al, 2005). Similarly, Gardner indicated that a child's interests, life experiences and skills all contribute to the development of creative abilities (Gardner, 1982 as cited in Claxton et al, 2005).

To sum up, whether or not different aspects of creativity develop in a linear fashion or with peaks and slumps over time, multiple factors need to be taken into account to explain the developmental trend of creativity. Besides cognitive factors (e.g. domain knowledge, divergent thinking skills), children's creative abilities are influenced by personal factors (e.g. risk-taking, being open to new experiences), and motivational and social factors (e.g. encouragement of children's curiosity, freedom of speech, avoiding destructive criticism) (Darvishi and Pakdaman, 2012). In co-design sessions, PD practitioners should be aware of this complex interplay of factors that may contribute to or work against a child's creative abilities. For instance, by setting up a collaborative atmosphere, stimulating children's intrinsic motivation and providing scaffolds for Design Thinking, as we aimed for in our research (cf. research question RQ1a).

4.4 Design Thinking

4.4.1 Definition and main characteristics

In PD practices, participants typically come from different backgrounds and design processes may be unknown to them. Therefore, it is useful to guide participants, in this case children, through the different steps and creative mechanisms of Design Thinking. This enables them to better reflect on their experiences and deeper levels of knowledge (e.g. latent and tacit needs, values), and to translate these into creative solutions for the design challenge at hand. The concept of Design Thinking refers to transferring designerly methods, tools and processes to other areas or people who are not trained as a designer. Brown provides the following definition of Design Thinking: "Design Thinking can be described as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008).

A central feature of Design Thinking is the recursive relationship between projective thinking (what could be) with reflective thinking on the impact of the projection (Kimbell, 2000). Although varying models exist, the Design Thinking process is typically visualized as running through several sequential phases: predesign, conceptual design, embodiment design, detailed design and implementation (e.g., Basadur et al., 2000; Baxter, 1995; Cross, 2000; Howard et al., 2008; Kryssanov et al., 2001; Thoring and Müller, 2011). Predesign involves gathering and analyzing information necessary to start the development of a new product concept. During conceptual design, ideas are generated and evaluated to solve particular design problems and to determine the product's desired functionality. During embodiment design the product components' structure is realized and specifications are refined. Once the design process has come into its detailed phase, the process of refinement continues towards a single global solution for the product's functional requirements and structure. Finally, during implementation, new solutions or products are put into action (Kryssanov et al., 2001).

Although the sequential order of these phases might suggest a linear model, the design process usually involves many iterations of going back and forth between the different steps. Moreover, in many Design Thinking models some form of integrated evaluation and selection of ideas and concepts is assumed. Separating the generation (i.e. divergence or creating choices) and evaluation of ideas (i.e. convergence or making choices) is regarded good practice for divergent thinking and creativity (Brown, 2008; Sutton and Hargadon, 1996).

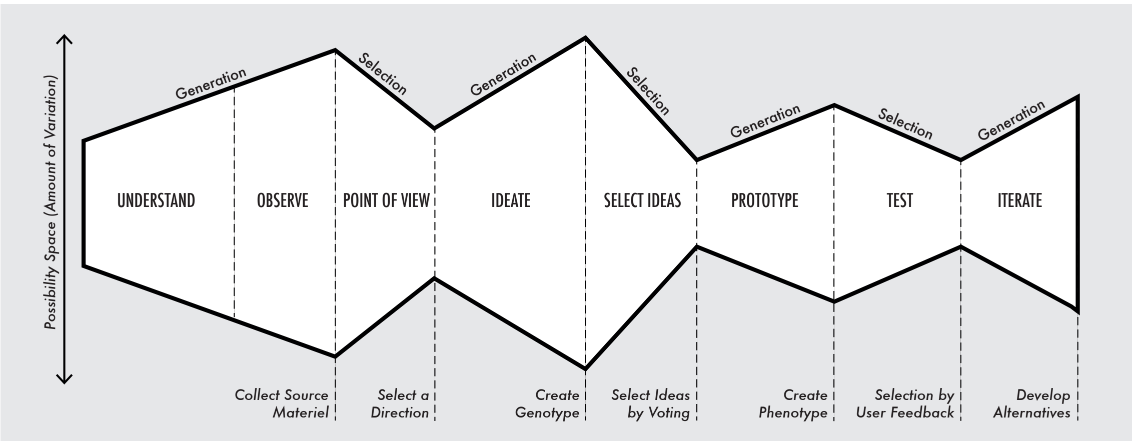

Figure 10: Thoring and Müller's Design Thinking model (2011) characterized by a constant alternation of expanding and reducing the possibility space

4.4.2 A model by Thoring and Müller

One particular divergent-convergent Design Thinking model that gained our interest is that of Thoring and Müller (2011). The model, that can be used by individuals and teams, is characterized by a constant alternation between expanding the design space through idea generation, also referred to as projective thinking, and reducing the design space through selection of ideas, also referred to as reflective thinking (see Figure 10). The different steps are: (1) understand, (2) observe, (3) defining a point of view, (4) ideation, (5) selecting ideas, (6) prototyping, (7) evaluating prototypes and (8) iteration. Although the consecutive steps may suggest a linear sequence, several iterations are required to run through the model.

4.4.2.1 Iteratively applied steps

The first two steps, understand and observe, correspond to the predesign phase mentioned earlier. In the first step, understand, existing information about the topic is gathered through secondary research. The second step, observe, is based on a qualitative research approach including different techniques such as in-depth interviews, observations, and generative techniques. Different insights are collected about problems, (latent) user needs and technological possibilities, which are then shared with the design team (Thoring and Müller, 2011). Others have referred to this phase as the fuzzy front end of design because of the ambiguity and chaotic nature that characterize it (Sanders and Stappers, 2008). In this phase, the possibility space is expanded, which means that as many options as possible are opened up. In the next step, defining a point of view, the insights of the first two steps are synthesized into a problem statement that determines the future focus. This first selection phase drastically reduces the possibility space and marks the end of the aforementioned predesign or fuzzy front end phase. The point of view functions as a micro-theory about the design problem. It reflects the users' perspectives and is often visualized (e.g. through personas, a mind map or a diagram) to enhance communication (Thoring and Müller, 2011). According to Sawyer (2008), the key is to establish a point of view that provides just enough focus to move the design team forward but, at the same time, is open-ended enough for problem-finding creativity to emerge (Sawyer, 2008).

During ideation, the next step, ideas concerning the problem are generated and the possibility space typically expands to its maximum. Ideas rarely come from nowhere and are often based on a recombination and mutation of previous insights and experiences (Thoring and Müller, 2011). However, that does not mean that the purpose of ideation is merely incremental improvement. Ideation is about "getting the right design", and only afterwards does the design team proceed with "getting the design right" (Greenberg & Buxton, 2008). Although different ideation techniques can be used that fall under the umbrella term brainstorming (e.g. gamestorming, brainwriting, extreme ideation), Osborn first coined the term in his book Applied Imagination (Osborn, 1953 as cited in Sutton and Hargadon, 1996). He proposed four basic rules for brainstorming ideas: "do not criticize", "quantity is wanted", "combine and improve suggested ideas", and "say all ideas that come to mind no matter how wild" (Osborn, 1953 as cited in Sutton and Hargadon, 1996). Other rules that are sometimes added to these four basic rules are "be visual" and "stay focused on topic" (e.g., Thoring and Müller, 2011).

After the brainstorming is complete, the best ideas are selected (e.g. by team voting), which reduces the possibility space and sets the focus on a small set of ideas to be developed further. Ideation and selection correspond with the conceptual design phase mentioned before.

In the next phase, prototyping, the selected ideas and solutions are visualized. A prototype can be a paper artifact, a photo story, a role-play or video, a working model or any other tangible artifact. During prototyping, the possibility space is slightly opened up again because new details and alternatives are considered to further develop the selected concepts. For that reason, more than one prototype is usually developed. Prototyping matches with the embodiment design phase stated earlier (Thoring and Müller, 2011).

In the testing phase, another concentration of the design space takes place. In this step, the prototype is taken to the users to gather feedback on the concept. The design team uses this feedback to revise the current prototype or to reconsider the whole concept. Sometimes it can even be necessary to go back to the first two steps, understand and observe, to gather additional insights and to completely rethink earlier made decisions. Collecting feedback from users is an iterative process of evaluation and adaptation. These iterations open up the design space once more because alternative solutions and improvements have to be figured out. Refinement of prototypes through iterative testing is also referred to as detailed design (Thoring and Müller, 2011).

4. 4. 2. 2 Dialectic of divergence and convergence

As shown in Figure 10, there are three steps within Thoring and Müller's Design Thinking process in which some kind of selection takes place, and even more steps once the process is iterated (Thoring and Müller, 2011). Selection is crucial, since the biggest challenge in

Design Thinking is usually not the development of a lot of ideas, but rather the selection of the right one. According to Guilford and Hoepfner (1971 as cited in Kryssanov et al., 2001), divergent thinking and convergent thinking are the two major low-level cognitive mechanisms at play in design processes. Divergent thinking is the ability to generate original, distinct and elaborate ideas, and convergent thinking is the ability to logically evaluate and find the best solution among a variety of feasible alternatives (Guilford and Hoepfner, 1971 as cited in Kryssanov et al., 2001). The dialectic process between divergence or creating choices and convergence or making choices is at the heart of Design Thinking (Brown, 2009).
Resuming the above we can conclude that Design Thinking is a progressive, purposeful and finite process that is sequenced in time and runs through several phases of divergence and convergence. At the same time, Design Thinking is nonlinear and continual, because cognitive processes are hardly ordered and human thought freely moves from one aspect of the problem to another (Kryssanov et al., 2001). This means that, in practice, the Design Thinking process is usually more erratic than suggested in most models.

As for our research (cf. research question RQ1a), we applied the dialect of divergence and convergence found in Thoring and Müller's (2011) Design Thinking model to co-design activities with children at the early, fuzzy front end of design. In small teams, children work together towards a shared design goal, thereby going through different stages of expanding and reducing the design space, which eventually results in one or more low-tech prototypes per team. The outcomes of children's collaborative and creative efforts are then used to inform and inspire the design of future technologies and practices for children.

4.5 Design-centered learning

Since children are not trained as designers, PD practitioners should provide scaffolds for Design Thinking by guiding children through the different steps of divergence and convergence. This will enable children to better reflect on their experiences, needs and values, and to translate these into creative solutions. Learning about the design process is one form of mutual learning that takes place when children and designers jointly and creatively explore the design space at the early stages of design. In addition, children learn about different technological possibilities, and designers gain insight into children's current practices and their ideas and aspirations for the future (Bratteteig et al., 2013; Kensing and Munk-Madsen, 1993). This learning does not develop through detached reflection, but through practice, which simultaneously encompasses action and reflection (Ehn, 1993).

Druin (1999) and Guha and colleagues (2010) have used the term design-centered learning to refer to the learning outcomes that come with design partnership. When people consider the outcome of a design process, it is usually the technology or prototype that is discussed. Although important, they suggest that what children can learn as a result of the research and development experiences is equally important. As research and design partners, children can learn about the design process, how to respect their design partners, how to communicate and collaborate in a team, and they can adopt new technology skills and knowledge (Druin, 1999). The authors furthermore argue that, although co-design practices are not intended as a method of teaching and learning in the traditional sense, a modified type of design partnering could be used in formal educational settings to learn children about Design Thinking and problem solving strategies (Guha et al., 2011).

Validating the social benefits of the act of being creative, Thorsteinsson (2002) argued in a similar fashion about the indirect benefits of involving children in design processes. He sees creativity as an integral societal necessity, being much more than transforming or adding value to products. Learning children about the creative mechanisms of Design Thinking enables them to have ownership over their environment. Such empowerment may lead to the strengthening and stability of future societies in which individuals can use their creative abilities to mold their environment and shape their destiny (Thorsteinsson, 2002).
A similar vision is found in Sternberg's (1997) concept of successful intelligence or the ability to succeed in life by attaining certain goals within a particular socio-cultural context. According to Sternberg, people can only achieve success by adapting to, shaping and selecting environments. This requires people to know their strengths and weaknesses and to compensate for these weaknesses by using analytical, practical and creative abilities (Sternberg, 1997)..
Both Sternberg's idea of successful intelligence, and Thorsteinsson and colleagues' view on the social benefits of the act of being creative, correspond well with PD's commitment to give those that will ultimately use or be affected by technology a voice in its design. PD's goal is above all to make people realize that they can have ownership over their environment, and that they do have a choice with regard to future technology (Bødker, 2003). Likewise, in this research, increasing children's agency and Design Thinking skills are important rationales.

4.6 Conclusion

In this chapter, we first discussed two underlying assumptions of co-design techniques, namely that everyone can contribute creatively to the design process, and that the socio-cultural context is an inherent part of the creative process. Afterwards, we looked into the concept of creativity from multiple perspectives, including how creativity develops over time. Whereas research in this area has focused primarily on cognitive aspects, more recently this focus has shifted to include motivational, social and personality factors, questioning how the latter aspects influence a person's creative abilities too. We concluded that PD practitioners should be aware of this complex interplay of factors when using co-design techniques. For instance, by setting up a collaborative atmosphere (see chapter *5. Perspectives on collaboration*, pp. 108) and scaffolding Design Thinking.

Design Thinking is characterized by a constant alternation of projective thinking to generate ideas (divergence), and reflective thinking on the impact of the projection, which reduces the design space (convergence). In the co-design toolkit that we developed as part of this PhD research, we relied on the Design Thinking model developed by Thoring and Müller (2011) discussed in this chapter. Our rationale is that by introducing the creative mechanisms of Design Thinking, children will be better able to reflect on their experiences and generate ideas for future technologies and practices. In addition, we hope that these newly gained Design Thinking skills will empower children to take ownership over their environment.

For more information on how we implemented Thoring and Müller's (2011) Design Thinking model, we refer to chapter *6. A reflective account of four cases* (pp. 124) and section *9.2 The CoDeT co-design procedure* (pp. 270) in chapter *9. Co-design toolkit*.

5. Perspectives on collaboration

5.1 Introduction

As argued in the previous chapters, Participatory Design (PD) assumes that future users of technology as well as other relevant stakeholders should play a critical role in its design (Schuler and Namioka, 1993). When designing technology for children, this implies that children should have a say in the direction and the outcome of the design process, and that their ideas and visions for the future should be taken into account.

Since children are physically and cognitively different from adults, their participation in the design process becomes even more important and may offer significant insights (Bruckman and Bandlow, 2002). However, due to these developmental differences and the traditionally unequal power relationships between adults and children, partnering with children in technology design asks for different methods, techniques and tools. Children's cognitive and socio-emotional developmental needs to be accounted for in co-design activities, as well as various contextual factors. Typical problems are children experiencing difficulties in expressing their thoughts and feelings, adult facilitators taking over the discussion, and the occurrence of challenging group dynamics between children because they are not used to collaborating in a team (cf. research question RQ1a).

As for the context in which the co-design activities take place, typical environments are a lab or space at the university or a classroom at school. In schools, where formal education instead of technology design is the primary objective, partnering with children usually results in a higher child-to-adult ratio compared to, for instance a typical Cooperative Inquiry study (e.g., Alborzi et al., 2000; Druin, 1999; Guha et al., 2013).

In Cooperative Inquiry, children and adults work together on a team as research and design partners for a prolonged period of time in a child-friendly lab at the university. This happens at a very low child-to-adult ratio (ca. 1 adult for 2 to 5 children), meaning that there are more adults for fewer children to facilitate the sessions and deal with challenging group dynamics between children. In contrast, a high child-to-adult (ca. 1 adult for 15 to 20 children) ratio implies that a broader variety of children can be involved, but that children have to work more autonomously towards a shared design goal with only minimal guidance from adult facilitators. Therefore, in order to collaborate constructively in co-design activities, children need to adopt appropriate social and interpersonal group skills, and they need to learn the creative mechanisms of Design Thinking.

To look for better ways to structure collaboration among children in co-design activities at a high child-to-adult ratio, we borrowed from other fields such as pedagogy and social psychology. Since co-design activities are a form of collective creativity in which two or more participants work together (see chapter *4. Design Thinking in co-design*, pp. 95), in what follows we first elaborate on what defines collaborative situations and interactions. Afterwards we discuss different Cooperative Learning approaches, their theoretical groundings, and optimal conditions and limitations for Cooperative Learning.

5.2 Collaborative situations and interactions

Most approaches that aim to involve children in design processes, such as Cooperative Inquiry (Druin, 1999), do not explicitly distinguish between cooperation and collaboration, although these concepts have different meanings. Dillenbourg distinguishes three criteria for a situation to be collaborative: a slight asymmetry of knowledge, symmetry of action and a common goal.

Symmetry of knowledge is the extent to which agents possess the same level of knowledge, skills or development. This level can change over time and can either be objective or subjective. Symmetry of knowledge should not be confused with heterogeneity, because two learners can have a similar degree of expertise but very different or heterogeneous views on how to approach the task (i.e., the actions it takes). Generally, a slight knowledge asymmetry among agents is considered as most beneficial for collaborative learning (Dillenbourg, 1999). Symmetry of action, in turn, is the extent to which the same range of actions is allowed to each agent (Dillenbourg and Baker, 1996). This criterion refers to the degree of division of labor among the group members. Whereas collaboration and cooperation are often used as synonyms, they are distinct with regard to the degree of division of labor. Whereas in a cooperative situation team members split the work, solve sub-tasks individually and then assemble the partial results into the final output, in a collaborative situation, group members do the work together. Finally, as for the third criterion, agents should have a common goal and work together towards that goal in order for a situation to be collaborative. Through the negotiation of goals agents do not only develop shared goals, but they also become mutually aware of their shared goals and that working together will improve their chances to succeed. Contrastingly, in a competitive situation, agents rely on conflicting goals meaning that the goal attainment of one agent inevitably results in failure for the others (Dillenbourg, 1999).

Besides criteria to determine whether or not a situation is collaborative, Dillenbourg furthermore distinguishes criteria for defining collaborative interactions among agents: interactivity, synchronicity and negotiability (Dillenbourg, 1999). As for the first criterion, the degree of interactivity among children is not defined by the frequency of the interactions, but by the extent to which these interactions influence their cognitive processes.
The second criterion is that collaboration implies rather synchronous communication, whereas cooperation is associated with asynchronous communication. Synchronicity is a social rule rather than a technical parameter, meaning that the speaker expects that the listener will wait for his message and will process the message as soon as it is delivered. However, conversational rules may differ depending on the medium and agents may create new ways of maintaining the subjective feeling of synchronicity accordingly (Dillenbourg, 1999).
Negotiability, a third and final feature of collaborative interactions, means that none of the agents will impose their view on the sole basis of their authority. At least to some extent they will argue for their point of view, and they will justify and negotiate it in an attempt to convince other agents (Dillenbourg, 1999). In order to do so, there should be space for misunderstanding, necessary for sustaining group members' efforts to overcome miscommunication. When group members misunderstand each other, they have to build explanations, justify themselves and reformulate statements, and in doing so learning and communication processes are enhanced. At least, if the level of misunderstanding is not too high (Dillenbourg, 1999).

Dillenbourg's (1999) criteria for collaborative situations and interactions provide an interesting lens to look at children's joined efforts in co-design activities. Based on the author's criteria, we aim for collaborative rather than cooperative situations and interactions in co-design activities with children. In the following section we discuss how children's collaboration can be improved according to an educational approach referred to as Cooperative Learning.

5.3 Cooperative Learning

5.3.1 Definition, roots and benefits

The term Cooperative Learning (CL) is used to refer to a broad range of teaching strategies in which two or more children learn or attempt to learn something together (Krol-Pot, 2005). Although Dillenbourg (1999) (see previous section) clearly distinguishes between cooperation and collaboration, in many writings on CL this distinction is not explicitly made. However, most CL approaches seem to aim for collaboration rather than cooperation. Johnson and colleagues (Johnson et al., 2000), for instance, define CL as those situations in which children work together to accomplish shared learning goals, and can only achieve their learning goals if and only if the other group members achieve theirs (Johnson et al., 2000; Johnson and Johnson, 1999). Thus, in a CL environment, children are not only focused on their own learning, but also on the learning of their group members. In theory, children in a CL environment have equal status and equal opportunities for success, implying a symmetrical relationship (Krol-Pot, 2005).

CL has its roots in socio-constructivism and sees learning as a constructive rather than a reproductive process. Learning is governed as much by social and situational factors as by cognitive ones, meaning that thinking and learning processes not only take place in the heads of people, but in constant interaction with the social, cultural and physical environment (Resnick, 1991; Shuell, 1996; Van der Linden et al., 1999). From a socio-constructivist approach, teaching is no longer regarded as the transfer of knowledge from teachers to students in the form of a monologue, but as orchestrating a complex environment of learners and activities (Shuell, 1996). In this conception of learning, the teacher transforms from being the sage on the stage to the guide at the side and children become active constructors of their own knowledge and meaning (Krol-Pot, 2005).

According to Slavin there are many benefits associated with CL. First of all, the use of CL in mainstream educational practice results in cognitive and non-cognitive outcomes (e.g. intergroup relations, self-esteem) (Slavin, 1995). Secondly, CL methods tend to enhance children's problem solving skills and their ability to integrate different types of knowledge and abilities. Fourthly, CL accords well with current conceptions of learning as a social, cultural and interpersonal constructive process that is governed as much by social and situational factors as by cognitive ones. Fifthly, since in CL children can learn from each other in heterogeneous groups, diversity in classes becomes a resource rather than a problem. Finally, as in a daily work environment people are expected to cooperate with each other, introducing CL in education may offer possibilities for adequate adult functioning in society (Slavin, 1995).

5. 3. 2 Theoretical perspectives on Cooperative Learning

The theoretical basis of CL can be divided into four main perspectives. The motivational and social cohesion perspectives focus on why agents put effort in collaboration, whereas the cognitive and cognitive elaboration perspectives focus on the mechanisms by which students learn from each other during cooperation.

5. 3. 2. 1 Motivational and social cohesion perspectives

The motivational perspective focuses primarily on the reward or goal structures under which children collaborate (Slavin, 1995). In a CL environment, a situation is created in which the only way group members can attain their own personal goals is through the success of the group. Therefore, to meet their personal goals, group members must both help their group mates to do whatever the group needs to succeed, and to encourage their group mates to exert maximum effort (Slavin, 1992). This way, an interpersonal reward structure is created in which group members give or withhold social reinforces in response to their group members' efforts (Slavin, 1995).

The social cohesion perspective is related to the motivational perspective in that the emphasis is on why children work together rather than on cognitive explanations for the effectiveness of CL (Slavin, 1992). According to the social cohesion perspectives, children will help one another, because they want one another to succeed, and not merely because it is in their own interest to do so. For the social cohesion perspective, children's intrinsic motivation to help each other learn and the cohesiveness of the group mediate the effectiveness of CL. A central feature of this perspective is an emphasis on teambuilding activities and group processing or self-evaluation in CL activities. Because of its potential negative influence on intrinsic motivation, social cohesion theorists typically downplay or even reject the use of group incentives and individual accountability held by motivational researchers to be essential (Slavin, 1995).

5. 3. 2. 2 Cognitive developmental and elaboration perspectives

The cognitive developmental and cognitive elaboration perspectives both focus on the learning mechanisms of CL and attribute CL's effectiveness to reasons associated with the mental processing of information rather than with motivations. The basic premise of the developmental perspective on CL is that interaction among children around appropriate tasks increases their mastery of critical concepts (Slavin, 1995). Within this perspective, two major

cognitive developmental theories can be distinguished: the constructivist theory of development also known as the Piagetian or socio-cognitive conflict perspective, and the socio-constructivist theory of development also known as the Vygotskian or socio-cultural perspective. What both theories have in common is the assumption that the social world plays a crucial role in children's cognitive growth, and that children take an active role in their own development (Tudge and Winterhoff, 1993).
In Piaget's theory (1970), constructivism is defined as a process in which the individual reflects on and organizes experiences both to create order in and to adapt to the environment (De Lisi and Golbeck, 1999). For children to attain higher levels of cognitive development, they have to deal with discrepancies between their own ways of viewing the world and new information, which leads to disequilibrium. By restructuring their thinking in order to provide a better fit with reality, their cognitive scheme (i.e., their way of viewing the world) is altered to integrate the new experiences and information. This way, the equilibrium is reestablished at a higher cognitive level (Tudge and Rogoff, 1989).
According to Piaget's theory, when children are engaged in learning tasks, the interactions in itself lead to improved achievement in CL. The reason is that in children's discussions cognitive conflicts arise and inadequate reasoning is exposed, which will eventually result in higher-order understandings (Slavin, 1995). In Piaget's (1970) view, peer interaction is superior to adult-child interaction, because under Unequal Power conditions the child may accept the adult's view without this process of cognitive restructuring that is necessary for cognitive growth (Tudge and Winterhoff, 1993).

Vygotsky's (1978) theory, in turn, focuses on the interdependence between the individual and the social context in learning and development. Whereas in Piaget's (1970) theory the unit of analysis is the individual who acts upon the world, in Vygotsky's theory children's cognitive development is mediated by social activities (Tudge and Winterhoff, 1993). When children participate in activities with more competent others and when they internalize the outcomes of the joint meaning-making process, they acquire new strategies and knowledge. However, this process of interaction between a child and a more competent other only stimulates cognitive growth if the interaction occurs within the child's zone of proximal development. Vygotsky (1978) defines the zone of proximal development as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky & Cole, 1978).

Thus, in Vygotsky's view, children's growth is promoted when they are engaged in collaborative activities, because children of similar ages are likely to be operating within each other's proximal zones of development (Hogan and Tudge, 1999). The resulting behaviors are more advanced than those of children who perform as individuals. Moreover, less competent children can move to higher levels of thinking with the help of more competent partners in collaborative activities. As such, knowledge is socially co-constructed (Hogan and Tudge, 1999).
According to Vygotsky, adult-child interaction is not inferior to peer interaction as in Piaget's theory, because the child should interact with a more competent partner, either an adult or a more competent peer. An important condition for cognitive growth, however, is that the more competent partner must comprehend the thoughts of the child and communicate comprehensively (Krol-Pot, 2005).

The fourth and final theoretical perspective on CL, cognitive elaboration, may be viewed as a specification within cognitive developmental theories (Krol-Pot, 2005). According to the cognitive elaboration perspective, information can only be retained in memory and related to information already in memory, if the child engages in some sort of cognitive restructuring or elaboration of the material (Wittrock, 1986 as cited in Slavin, 1995). One of the most effective means of elaboration is explaining the material to someone else, which is not only beneficial for the tutee but also for the tutor (Devin-Sheehan et al., 1976 as cited in Slavin, 1995). Thus, when children work together, it is important that they verbalize their thoughts, because verbalization elicits elaborative cognitive processes that produce reflection, awareness, reorganization, differentiation, fine-tuning, and, ultimately, the expansion of knowledge (Van Boxtel, 2000 as cited in Krol-Pot, 2005).

The four perspectives on CL are not mutually exclusive and may be seen as complementary. Motivational theorists usually do not argue against cognitive theories, but instead argue that motivation drives cognitive processes, which in turn produces learning. For instance, group goals can be used to motivate children to take responsibility for one another independently of the teacher. Hence, problematic group dynamics and classroom organization problems can be solved and more opportunities for cognitively appropriate learning activities can be created (Slavin, 1995).

5.3.3 Cooperative Learning approaches

According to Johnson and colleagues, the combination of theory, research and practice makes CL a powerful learning procedure (Johnson et al., 2000). This does not mean that all operationalizations of CL are equally effective. The various approaches to CL differ with regard to the reward structure (use of incentives or not), group composition (homogeneous versus heterogeneous), group size (e.g. dyads, small groups of 4 to 6 children or large groups), type of tasks (e.g. rehearsal, integrative, exploratory, skills), and the role of the teacher (e.g. director, facilitator or guide) (O'Donnell, 2001).

The varying approaches to CL can furthermore be placed on a continuum from direct to conceptual. More direct CL methods consist of specific well-defined techniques that teachers can learn in a short period and apply immediately. The same direct procedures can be used in different educational situations (Johnson et al., 2000). In turn, more conceptual CL methods consist of conceptual frameworks that teachers can learn and use as a template to restructure lessons and activities in collaborative ones. With conceptual procedures, teachers can create CL lessons to fit their specific circumstances, which make conceptual CL methods much more adaptable to changing conditions (Johnson et al., 2000). Whereas the direct methods may initially be more appealing in terms of user-friendliness, once mastered, the conceptual methods are more frequently maintained over time and easier to adapt to changing conditions and circumstances (Antil et al., 1998).

5.3.3.1 A continuum from direct to conceptual

Slavin and colleagues developed a number of CL methods to apply in heterogeneous groups under the name Student Team Learning. These methods are direct in nature and easy applicable by teachers. The Student Team Learning methods all have in common that they incorporate team rewards, individual accountability and equal opportunities for success. The primary objective is to increase children's achievement rather than to develop interpersonal skills, because children are supposed to be (extrinsically) motivated to collaborate and learn together in order to obtain the group reward. Hence, the work of Slavin reflects a motivational perspective on CL, in which the focus is primarily on the reward or goal structures (Slavin, 1983).

Two CL methods that can be placed somewhere in the middle on the continuum from direct to conceptual approaches are the Jigsaw method (Aronson et al., 1978) and Sharan's Group Investigation Method (Sharan and Sharan, 1989). In the Jigsaw method, children study material on one of four or five topics distributed among team members. After studying the material individually, children meet in expert groups to share information on their topics with members of other teams who studied the same topic. Afterwards they meet with their team and they present what they have learned about their topic (Aronson et al., 1978). In the Group Investigation method, teams take on topics within a unit studied by the class as a whole, and then further subdivide the topic into tasks within their team. When each team has investigated their topic, all teams meet and present their findings to the class as a whole (Sharan and Sharan, 1989). Both Jigsaw and Group Investigation are task specialization methods that rely heavily on the social cohesion perspective of CL (Slavin, 1995).

Another method developed by Kagan (2001a, 1994) is the Structural Approach that aims to provide teachers with a flexible and eclectic way to implement CL in their classrooms. Although Johnson and colleagues (2000), classify the Structural Approach as a direct approach to CL, Kagan (2001b) argues that his method is conceptual in nature. The reason is that once teachers obtain a stable repertoire of structures, they can turn any lesson in a collaborative one with little effort.

A structure is a content-free way of organizing the social interaction among students in a classroom. When educational content (what is learned) is combined with a certain structure (how it is learned) a CL activity is created (Kagan and Kagan, 1998). Kagan has developed over 150 structures that teachers can learn and integrate into a repertoire of structures for classroom use. For instance, think-pair-share is a three-step structure in which children first think individually about a question, then pair up with a neighboring child to discuss their ideas and, finally, share their ideas discussed in the pairs with the entire group. As with other structures, think-pair-share can be used with any content and in divers circumstances (Kagan, 2001b).

5. 3. 3. 2 Learning Together and Social Interdependence Theory

A conceptual approach to CL that straddles the motivational and social cohesion perspectives can be found in the work of Johnson and Johnson (1994). In their Learning Together method, group goals and incentives are combined with teambuilding activities and group self-evaluation to strengthen the team's social cohesion. For Johnson and Johnson, who based their work on Lewin (1948) and Deutsch (1962, 1949), the Social Interdependence Theory is an important perspective that guides research into CL. From this perspective it is assumed that the way in which social interdependence is structured determines how individuals interact, which, in turn, determines outcomes (Johnson and Johnson, 2005, 1989) (see Figure 11). In the Learning Together method teachers structure five mediating principles in their lessons to facilitate children's psychosocial development. The combination of these five principles, argued by Johnson and Johnson (2005), is essential for a lesson to be collaborative. The five mediating principles are positive interdependence, individual accountability, face-to-face promotive interaction, interpersonal and small-group skills and group processing.

- Positive interdependence is the most essential element of CL and concerns the perception of team members that they have to work together to accomplish a common goal. When positive interdependence is structured adequately, children perceive that their effort is important for the entire group. On the contrary, negative interdependence means that there is a negative correlation among children's goal attainments such as in a competitive situation (Johnson and Johnson, 2005).
- Johnson and Johnson (2005) distinguish between three types of positive interdependence. Outcome interdependence refers to team members sharing the same goals and perceiving that collaboration is essential to achieve these goals. Means interdependence is established when team members depend on one another for resources and abilities to achieve these shared goals. Boundary interdependence means that team members experience a shared identity (cf. social cohesion) and, as a consequence, are intrinsically motivated to help one another to succeed (Johnson and Johnson, 2005).
- Individual accountability, in turn, means that children are held responsible for their contribution to achieving the shared goal. In CL, it is important that children realize that they themselves are responsible for the teamwork and that each has an equal role to play in achieving the shared goal. Individual accountability makes it possible for the teacher to detect the contribution of each student, and at the same time, results in feelings of responsibility among team members for completing their share of the work and facilitating the work of others in the team (Johnson and Johnson, 2005).
- Promotive interactions refers to team members that meet face-to-face to facilitate each other's efforts to accomplish the shared goals. Positive interdependence strengthens promotive interactions between children and positively influences their efforts to achieve caring and committed relationships. When engaged in promotive interactions, children encourage each other and work constructively towards mutual goals. On the contrary, negative interdependence such as in a competitive situation leads to oppositional or contrient interactions (Johnson and Johnson, 2005).

- In order to be productive, children must be taught the interpersonal and small-group skills required for high-quality collaboration, such as active listening, turn taking, good questioning and argumentation. The quality and quantity of learning depend on children's interpersonal and small-group skills as well as on the motivation to use these skills. They are essential to cope with the stresses and strains of working in a team, and are a precondition for promotive interactions to occur (Johnson and Johnson, 2005).
- The fifth and final mediating principle, group processing, refers to children reflecting on how well the team is functioning by considering which actions were helpful and unhelpful, and deciding upon which actions to continue or change. To continuously improve their work over time, teams need time to discuss how well they are achieving their goals and maintaining effective working relationships among team members. Group processing has a positive impact on children's interpersonal and small-group skills and fosters promotive interactions (Johnson and Johnson, 2005).

According to Johnson and Johnson (1999), the role of the teacher in CL should be that of a guide on the side. In their Learning Together method, teachers first have to make a number of pre-instructional decisions regarding learning objectives, group composition, role assignments and arrangement of the room and the materials. Then, the teacher has to explain the instructional tasks and the collaborative nature of the lesson. This includes explaining the criteria for success and individual accountability, structuring positive interdependence among the teams and scaffolding productive interactions. Once children start collaborating, the teacher has to monitor the different learning groups and intervene when needed, and eventually bring the lesson to closure. Finally, the teacher evaluates and processes the results, which includes assessing children's achievements, ensuring children process the effectiveness of their learning and having children celebrate their teamwork (Johnson and Johnson, 1999).

What we took away from these Cooperative Learning approaches are the five mediating principles for effective collaboration as applied in the Learning Together method (Johnson and Johnson, 1994). We merged these principles with Thoring and Müller's (2011) Design Thinking model (see chapter *4. Design Thinking in co-design*, pp. 95) in order to scaffold children's collaboration and creativity in co-design activities (cf. research question RQ1a).
For instance, in case 2 (see chapter *6. A reflective account of four cases*, pp. 124) we made team members interdependent on one another by increasing task and social cohesion, and

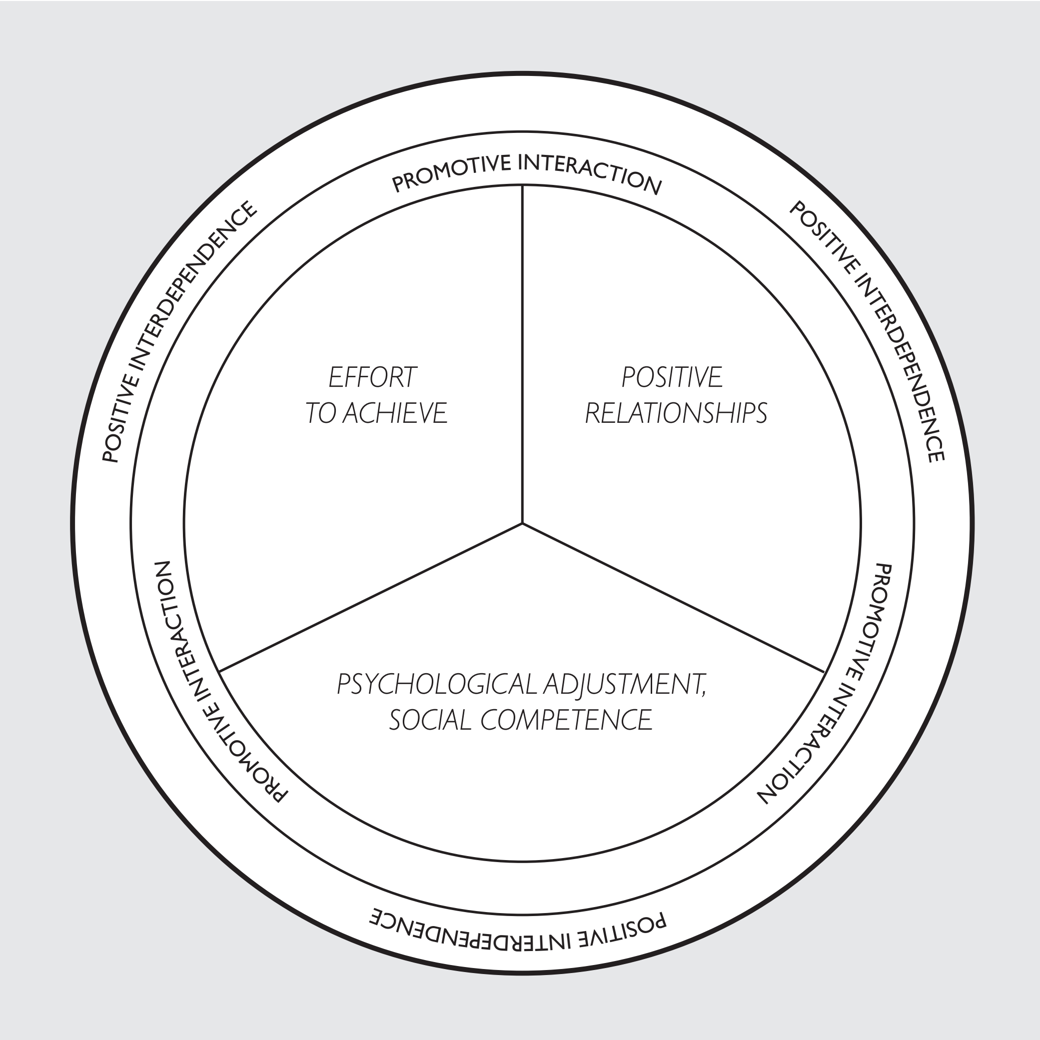

Figure 11: According to Johnson and Johnson (2005), positive interdependence between individuals results in promotive interactions which in turn leads to positive outcomes.

by giving each child a special role and responsibility within the team (cf. positive interdependence). Also, we specified the preferred interactions to negotiate a design solution (cf. promotive interactions), and gave children time to practice their interpersonal and small-groups skills. In addition, children were prompted to reflect on the collaboration process and how it could be improved at the end of each co-design session (cf. group processing). By installing a peer jury in which teams presented their final prototype and the other teams evaluated it, we furthermore created a sense of group accountability. Similar techniques are integrated in chapter *9. Co-design toolkit* (pp. 269).

5.3.4 Pitfalls and optimal conditions for Cooperative Learning

When children work together in teams following a CL approach, they gradually become interdependent in a reciprocal manner, meaning that their cognitive processes affect and become affected by those of the other team members. However, this does not mean that all teams work well. Teams may perform below their potential, because children lose motivation and start to loaf, which means that they do not exert maximum effort. In some cases, even the team as a whole may reduce its effort and begin to loaf (Krol-Pot, 2005).

5.3.4.1 Social Loafing

Two common loafing practices are the free rider and the sucker effect. A free rider effect occurs when a group member seeks a free ride by leaving it to the others to complete the teamwork. The sucker effect is closely related to the free rider effect and occurs when a more competent group member discovers over time that he or she has been doing all the work for the team. Thus, to avoid being taken advantage of, this more competent group member expends less effort (Krol-Pot, 2005). Free Riding typically occurs when it is difficult to identify individual contributions, when contributions are overlapping and redundant, or when not all group members are responsible for the outcome of the group (Johnson and Johnson, 1994). Furthermore, the free rider effect may increase when a disjunctive task is used in which performance depends on the performance of the most able child, or a conjunctive task in which performance depends on the least able child. The free rider effect may further increase as the group size augments
(Krol-Pot, 2005).

One or more group members can cause detrimental effects, but it is also possible that the whole team decides to gang up on the task (Salomon and Globerson, 1989 as cited in Krol-Pot, 2005). Either way, for teachers implementing CL in their classrooms it is important to be aware of these intragroup dynamics (i.e. a system of behaviors and psychological processes occurring with a social group) and intervene when needed (Krol-Pot, 2005). Likewise, in co-design activities with children, these and other group dynamics should be accounted for. Moreover, in some cases, intervention by an adult facilitator may be required to safeguard a collaborative atmosphere in the team (Van Mechelen et al., 2015b, 2014a).

5. 3. 4. 2 Improving collaboration

The fact that not all teams operate at their full potential and in a constructive manner, raises the question under which conditions CL is optimally effective. Research has suggested that Social Loafing practices are less likely to occur when group members are held accountable for doing their share of the work (Johnson and Johnson, 2005; Slavin, 1995). When CL methods lack individual accountability, the outcome of the teamwork could theoretically have been done by only one group member (Latane et al., 1979 as cited in Slavin, 1995).

In contrast, CL methods that lack group goals give children only individual grades or feedback without any consequences for doing well as a group. Therefore, CL has its greatest effects on children's learning when groups are recognized or rewarded based on individual learning of the group members (see, for instance, Ellis and Fouts, 1993; Newmann and Thompson, 1987; Slavin, 1995). The importance of group goals and individual accountability lies in providing children with an incentive to help and encourage each other to put forth maximum effort (Johnson and Johnson, 2005; Slavin, 1995).

One category of tasks that may not require group goals and individual accountability are controversial tasks, such as tasks in which it is likely that students will benefit by hearing others thinking aloud (Slavin, 1995). Controversial tasks have a very high level of cognitive complexity, but no well-defined path to a solution or a single correct answer. Here, the process of participating in arguments or listening to the opinions and envisioned solutions of other team members may be enough to enhance learning, even without any form of assessment on an individual or group level (Slavin, 1995). When tasks are not controversial in nature, additive tasks in which performance depends on the maximal contribution of all group members are recommended to avoid loafing practices. For instance, in the multiple-abilities treatment, the teacher creates a mixed set of expectations for each child. In this way, the teacher convinces children that many different abilities are required in order for the group to achieve the joint goal, and that each group member will be good at some of these abilities but no member will be good at all these abilities (Krol-Pot, 2005).

Another way to make collaborative groups more effective, even in the absence of group rewards or individual accountability, is by structuring group interactions. Meloth and Deering (1992), for instance, discovered that children's collaborative efforts were much more effective when they were taught specific strategies and given think sheets to remind them to use these strategies (Meloth and Deering, 1992). Similarly, research on Reciprocal Teaching shows how direct strategy instruction can enhance CL (Palincsar and Brown, 1984). In this method, the teacher works with a small group of children and teaches cognitive strategies such as question generation and summarization. After a while, the teacher starts to turn over responsibility to the children to carry on these activities with each other, which results in cognitive and interpersonal behaviors that lead to higher achievement, without the need for group rewards (Meloth and Deering, 1992; Palincsar & Brown, 1984).

These techniques to create optimal conditions for CL are not mutually exclusive with the five mediating principles for effective collaboration as applied in the Learning Together method (see previous section). Structuring group interactions and providing strategies for question generation aligns with the principle promotive interactions for which adequate interpersonal and small-group skills are required. Creating mixed sets of expectations for each child responds to the principle positive interdependence, that can be implemented by giving each child a special role and responsibility in the team. In addition, by providing team incentives for solving the design problem (e.g. design certificate, cup for the winning team), feelings of responsibility and accountability towards the team can be further strengthened.

5.4 Conclusion

In this chapter, we looked for appropriate ways to structure collaboration between children in co-design activities (cf. research question RQ1a). First, we discussed criteria for collaborative situations and interactions, which provide a useful lens to look at children's creative efforts in co-design activities. Afterwards, we focused on an educational approach known as Cooperative Learning, developed to facilitate two or more children to learn something together. Cooperative Learning has its roots in socio-constructivism and sees learning governed as much by social and situational factors as by cognitive ones. Similarly, co-design techniques rely on the assumption that the socio-cultural context is an inherent part of the creative process, and that making creativity more open and social through participatory processes will increase positive outcomes (see chapter *4. Design Thinking in co-design*, pp. 95).

For the co-design toolkit developed as part of this PhD research, we relied on one specific approach to Cooperative Learning: the Learning Together method. This method, which is based on Social Interdependence Theory, straddles a motivational and social cohesion perspective on Cooperative Learning. The goal of the Learning Together method is to increase children's willingness to collaborate and learn together. According to the method and its underlying theory, the combination of five mediating principles is essential for an educational activity to be collaborative: positive interdependence, individual accountability, promotive interactions, adequate interpersonal and small-group skills, and group processing. We argue that applying these principles to co-design activities will enable children to collaborate productively towards a shared design goal. In this way, challenging group dynamics such as Social Loafing practices can be reduced.

For more information on how we implemented these mediating principles, we refer to Van Mechelen and colleagues (Van Mechelen et al., 2015b) in chapter *7. Publications research question RQ1a* (pp. 181), and chapter *6. A reflective account of four cases* (pp. 124). The resulting co-design procedure for which we also relied on Thoring and Müller's (2011) Design Thinking model (see chapter *4. Design Thinking in co-design*, (pp. 95) is presented in section *9.2 The CoDeT co-design procedure* (pp. 270) in chapter *9. Co-design toolkit*.

6. A reflective account of four cases

6.1 Introduction

This chapter offers a reflexive account of four cases that were conducted as part of this PhD research. In a linear fashion, it tells the story from our initial research questions until the development of the co-design toolkit, and discusses how we expanded and took forward our knowledge from one case study to the next. In order to do so, cross-references are made with literature and output chapters, and some previously discussed theories and concepts are reiterated to make a coherent story. Also, this chapter is written in a more narrative style compared to the previous chapters.

For each of the cases discussed in this chapter, the overarching research question was how to design technology for children with children in a school context. The first case study was the most exploratory one because the research questions were not yet fully defined. In the second case study we focused more in-depth on the problem of challenging group dynamics between children (cf. research question RQ1a) and on the problem of analyzing co-design outcomes (cf. research question RQ1b). The second research question was also addressed in the third case study, and the first research question in the fourth case study. Each of these four individual cases had a separate embedded case, being the design challenge that was addressed in the co-design activities and that was determined by the project. The outcomes of these embedded cases are not the focus of this PhD, and are only discussed when considered relevant for the research questions (RQ1a and RQ1b). These research questions link the different cases together into a multiple-case embedded design (for more information, see chapter *2. Methodology*, pp. 67).

6.2 Case 1: Arts and culture education for children

6.2.1 Rationale

For the first case study, we collaborated with two Flemish organizations: Cultuurnet Vlaanderen and Canon Cultuurcel. The project (cf. embedded case) aimed at discovering new opportunities and ideas for a mobile application for children that would facilitate them to learn about culture and arts in a playful manner. By involving children as design partners, our goal was to gain insight into their experiences, and to collaboratively generate ideas for future technologies and practices.

As for our PhD research, we were interested in how children could participate in an appropriate and meaningful way at this early stage of the design process. At the time, we had no experience with involving children in design, so we borrowed from existing approaches: the use of generative techniques as described by Sleeswijk Visser and colleagues (Sleeswijk Visser et al., 2005) in their Contextmapping procedure, and Druin's (1999) Cooperative Inquiry approach (for more information on both approaches, see chapter *1. Participatory Design with children*, pp. 25). In addition, we used Thoring and Müller's (2011) Design Thinking Process to structure different, consecutive stages of divergence and convergence (see chapter *4. Design Thinking in co-design*, pp. 95).

6.2.2 Method

The study took place in three schools, one of which was located in an urban region and two schools in suburban regions in Flanders, Belgium. By involving multiple schools in different regions, a wide variety of children could be included in the design process. In one school, two class groups participated and in the other schools one class group. All children were in the fourth grade of elementary school, aged 9 to 10. In total, 103 children were involved in five co-design sessions and a general introduction, resulting in six visits per school.

For the first three co-design sessions, each class group, ranging from 19 to 30 children, was divided in a morning- and afternoon group. At the beginning of each co-design session, these morning- and afternoon groups were split up in two to three gender-mixed subgroups of four to six children. Literature recommended this as the most optimal group size (e.g., Heary and Hennessy, 2002). In addition, it was suggested that heterogeneous groups are more capable of coming up with diverse ideas (Sawyer, 2008; Sutton and Hargadon, 1996). Therefore, with the help of the teachers, these subgroups were formed heterogeneously, based on criteria such as intelligence, communication skills and creative abilities. For the fifth and sixth co-design session, we limited the number of children per class group to one heterogeneous team of five boys and girls (see Table 1).

Over a period of two months, five co-design sessions were organized in each class. We thereby divided the design challenge into different subtopics, one for each session:

- Session 1: organizing a fun and engaging class excursion
- Session 2: making schoolwork both fun and engaging
- Session 3: designing a fun and engaging website for learning
- Session 4: inventing technology to assist school children on a museum visit
- Session 5: evaluating ideas and designs from teams in other schools via a blog

Two researchers were involved in each co-design session: one facilitator interacted with the children while one fly-on-the-wall observer made notes about the group process. In addition, the session was recorded on video and a report about the co-design process was written immediately afterwards. In these reports we focused on the collaboration between children, how they approached the different design tasks and the amount of facilitation that was needed.

	School 1		School 2				School 3	
	Class A		Class A		Class B		Class A	
	AM	PM	AM	PM	AM	PM	AM	PM
Session 1	4 boys 5 girls	5 boys 5 girls	7 boys 7 girls	7 boys 6 girls	8 boys 5 girls	8 boys 6 girls	8 boys 8 girls	6 boys 8 girls
Session 2	5 boys 3 girls	3 boys 6 girls	7 boys 7 girls	7 boys 7 girls	8 boys 5 girls	8 boys 5 girls	8 boys 8 girls	6 boys 7 girls
Session 3	6 boys 3 girls	3 boys 6 girls	7 boys 6 girls	8 boys 5 girls	8 boys 5 girls	8 boys 5 girls	8 boys 8 girls	6 boys 7 girls
Session 4	3 boys 2 girls		2 boys 3 girls		3 boys 2 girls		2 boys 3 girls	
Session 5	3 boys 2 girls		2 boys 3 girls		3 boys 2 girls		2 boys 3 girls	

Table 1: Total amount of participants in case 1: 103 children aged 9 to 10 in 3 schools, divided in morning (AM) and afternoon (PM) groups (except for session 4 and 5), and subdivided in teams of 4 to 6 boys and girls

The co-design sessions lasted for about 120 to 150 minutes and typically consisted of the following stages:

- Introduction and warm up
- Ideation and selection
- Elaboration through making
- Presentation and discussion

Approximately two weeks ahead of the first co-design session, we introduced sensitizing packages in the children's classrooms. The idea to sensitize children before the first session was borrowed from the Contextmapping procedure (Sleeswijk Visser et al., 2005). The packages contained three individual assignments that needed to trigger children's reflection and curiosity about the design theme in a playful and creative way. When we introduced the packages, we explained the overall purpose of the assignments and that children had to work on these assignments at home. We furthermore made arrangements about how much time children had for each assignment, and when we would pick up the results. Each assignment was put in a sealed envelope to add an element of surprise. Only when children handed in their work for one assignment, which they had to drop in a box in front of the classroom, they received the next envelop from their teacher. The sensitizing assignments were:

- 1st assignment: What would your ideal classroom of the future look like? What would be in it? Make a drawing or collage of your ideal classroom.
- 2nd assignment: If you could organize a fun and educational class excursion, what would it be? Make a drawing or collage of your class excursion.
- 3rd assignment: Online media diary: what did you do online and how did you like it? Fill in this diary for one week.

The results of the sensitizing assignments (see Figure 12) were collected and briefly analyzed before the first co-design session. Through this quick analysis, we wanted to get a better grip on children's interests and, if necessary, adapt the co-design activities accordingly. The sessions took place in an available room in the school building. After dividing the children into teams, we explained the design problem and the overall goal of the session, which we had already defined beforehand. We did not clarify how children should collaborate with their team members, nor did we provide any rules or boundaries, because we wanted to be on an equal footage with children as proposed in the Cooperative Inquiry approach (Druin, 1999; Guha et al., 2013). Before moving on to the ideation and selection phase, we asked the teams to briefly discuss the results of the second sensitizing assignment as an additional warm-up.

For the next stage, ideation and selection, children negotiated a solution for the design challenge with their team members. We handed out sticky notes and markers and explained the rules for ideation, which were based on Osborn's (1953) seminal book on brainstorming: there are no bad ideas, encourage wild ideas, build on the ideas of others and go for quantity (see section *4.4.2.1 Iteratively applied steps* on pp. 103 in chapter 4. Design Thinking in co-design). Teams were encouraged to write as many ideas as possible on sticky notes without thinking about the quality of the ideas yet. Relying on Thoring and Müller's (2011) Design Thinking model, we separated the divergence and convergence of ideas, because this is considered good practice for creative thinking (see section *4.4.2 A model by Thoring and Müller* on pp. 103 in chapter *4. Design Thinking in co-design*). Afterwards the teams grouped similar ideas together and team members voted for their favorite ideas by placing a sticky dot on the corresponding ideas (see Figure 13). Thus, while the possibility space expanded during ideation, it was drastically reduced in the selection phase.

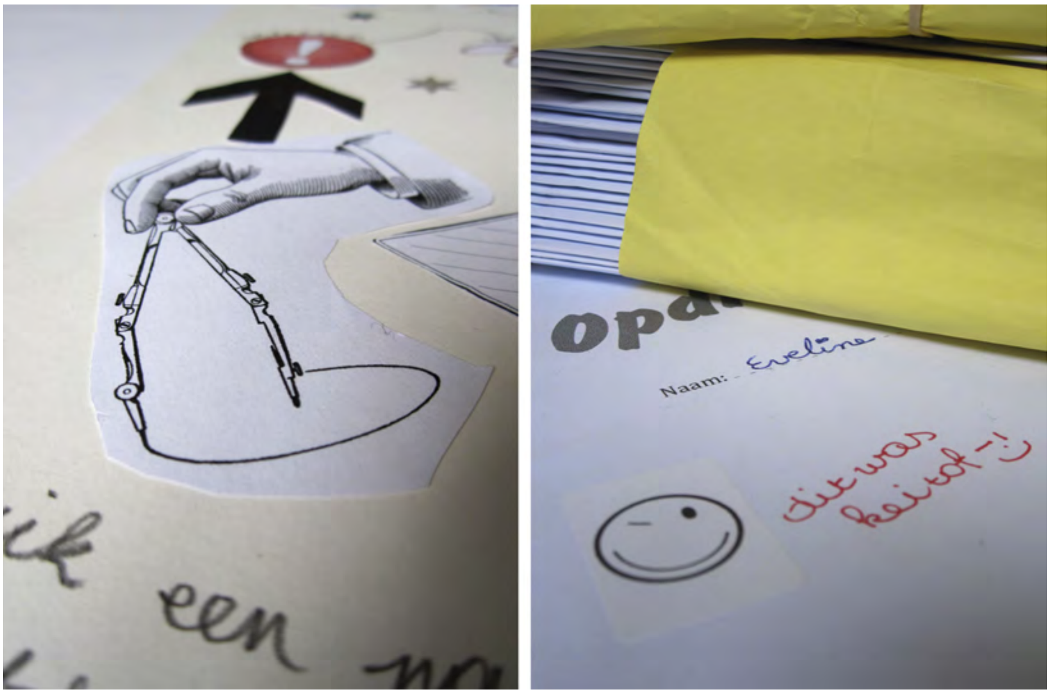

Figure 12: Results from the sensitizing assignments in the first case; on the left a close-up of a collage illustrating a child's ideal classroom of the future.

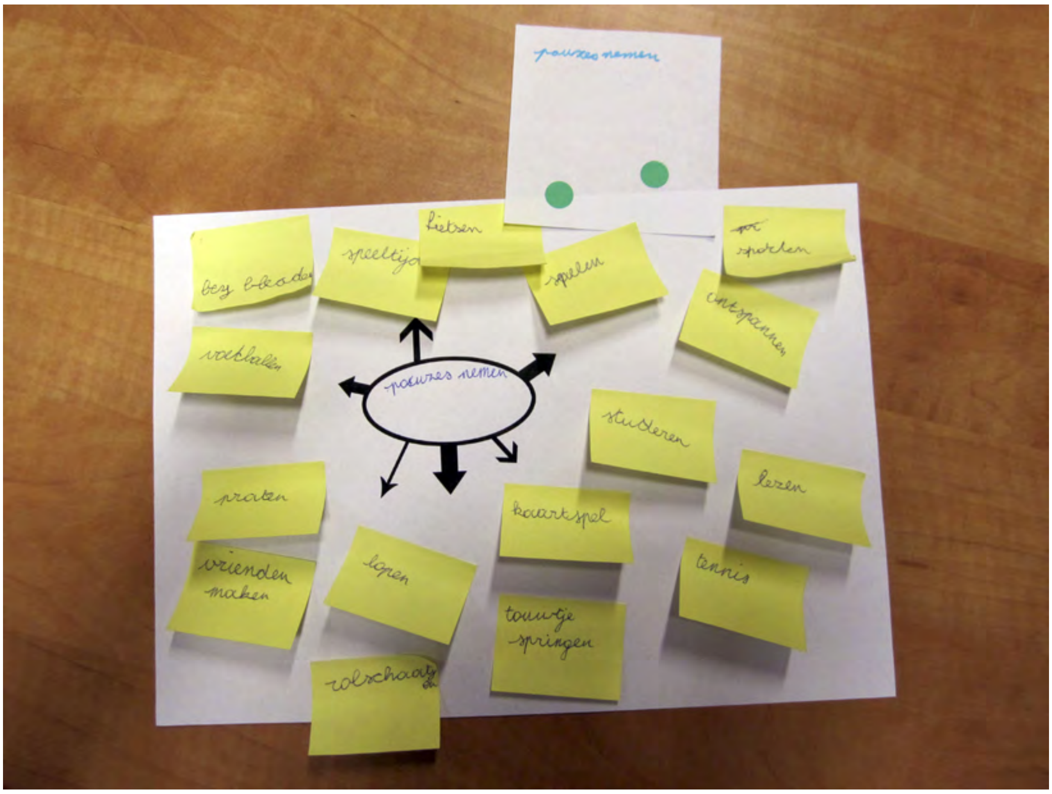

Figure 13: Results from the ideation and selection phase in which teams brainstormed ideas for a design solution and, afterwards, selected the most promising ideas through sticky dot voting.

The three most popular ideas were taken to the next stage, elaboration through making, for further development. In a hands-on way, teams elaborated on these ideas. Inspired by the Mixing Ideas technique (Guha et al., 2004), we explicitly asked to integrate the three selected ideas into one big idea, and to visualize this big idea through a collage (see Figure 14). This implied that new details could be considered and that the possibility space would slightly open up once more as suggested in Thoring and Müller's Design Thinking model (2011). For making the collage, teams could rely on a generative toolkit consisting of cardboard, colored papers, markers, crayons, Styrofoam, and other materials.

Finally, we asked each team to present their collage during a show and tell moment, while the other teams were asked to listen carefully and, afterwards, ask questions. We moderated this discussion and asked some open-ended questions ourselves in order to arrive at a better understanding of children's designs. Presentations and discussions were all recorded on video for further analysis. The session ended with a short wrap-up in which we explained what would happen with their designs.

Figure 14: A co-design team visualizing their big idea through a collage during the elaboration through making phase.

For the analysis of the co-design outcomes, we used an inductive, grounded theory based approach as suggested in the Contextmapping procedure (Sleeswijk Visser et al, 2005). We thereby relied on children's verbal explanations of their designs, which we considered as most inspirational and insightful at that time. First we transcribed children's presentations and discussions, and then we coded these transcripts bottom-up to identify recurring themes and ideas. These results were used to inspire the further design process and, ultimately, to develop a working concept. For the research question on how to involve children in an adequate and meaningful way at the early stages of design, we analyzed observation reports and video footage of the co-design sessions.

6.2.3 Expectations

We had four main expectations with regard to the co-design procedure for which we relied on Contextmapping (Sleeswijk Visser et al., 2005), Cooperative Inquiry (Druin, 1999), and Thoring and Müller's Design Thinking model (2011). Firstly, we expected that the process of sensitization would increase children's interest for the design challenge, and, as a consequence, their willingness to participate in the design process. Because we introduced the sensitizing packages two weeks ahead of the first co-design session, children had time to reflect on the design challenge. We assumed that this would help children to identify their needs, which in turn would result in more relevant ideas for educational technologies during the co-design sessions.

Secondly, based on Thoring and Müller's (2011) Design Thinking model, we considered it good practice to separate the divergence and convergence of ideas in consecutive stages (ideation, grouping ideas, selection, elaboration through making). Introducing these creative mechanisms of Design Thinking was believed to compensate for children's lack of experience as design partners. In addition, by making creativity into an open and social process, we hoped to further strengthen children's creative abilities in co-design activities.

Thirdly, we considered the act of making as a very direct way for children to express themselves, because they are quite familiar with these kind of activities (e.g. drawing, making collages). We assumed that the creative and playful character of making activities would keep children engaged. Moreover, relying on Sanders' (2002, 1992; Sanders and Simons, 2009) work on generative techniques, we expected that the act of making in itself would reveal needs or "dreams for the future" that children were not yet aware of or would find hard to immediately express in words.

Finally, as for children's abilities to collaborate constructively in small teams, we were not sure what to expect. Druin (2002, 1999) argues that 9 to 10 year olds are verbal and self-reflective enough to discuss what they are thinking, and understand the abstract notion that their ideas will be turned into technology in the future. However, we assumed that there would be large individual differences between children, and that children's previous experience with teamwork would be decisive, and would largely depend on the school- and class culture.

6.2.4 Findings and observations

6.2.4.1 Facilitating the co-design activities

After Session 3 we took some time to reflect on the co-design process so far. In contrast to our expectations with regard to involving children as design partners (see previous section), we experienced numerous challenges. With regard to the sensitizing assignments, the main problem was that not all children handed in their work. Most children had put a lot of effort in their drawings and collages, which offered a great source of inspiration. Unfortunately this was not the case for all children. Despite our clarification for how and when to hand in the assignments, we probably should have double-checked whether children truly understood what was expected from them. Another possible cause is that not all children were that interested in the design challenge, indicating a lack of intrinsic motivation. To tackle this problem, we probably should have spent more time and energy in creating a sense of problem ownership.

Most issues, however, were faced during the actual co-design sessions during which children collaborated in small teams of four to six children. We noticed that some children did not fully understand the design challenge, but started generating ideas anyway. Others were afraid to do something wrong and got stuck in right or wrong thinking, constantly asking for our approval, which might have hampered creative thinking. In addition, shy and less verbal children often had a hard time getting their voices heard during the co-design activities. Some children, especially boys, acted rather silly and did not seem fully committed to solving the design problem.

There were also teams who got lost in irrelevant details and gradually got off track during the co-design activities. For instance, in some teams, a lot of time and energy was devoted to the material look and feel of the design while neglecting the actual design problem. Some exceptions notwithstanding, teams also had a hard time integrating different ideas into one big idea during the elaboration phase, as suggested by Guha and colleagues (2004). Despite these challenges, positive team dynamics were also observed. For instance, some children acted as natural leaders who used their power in a positive manner, resulting in constructive negotiating processes among the team members.

Finally, as facilitators, we experienced difficulties in managing three teams of four to six children at the same time. Only one researcher facilitated the sessions while another researcher functioned as a fly-on-the-wall observer who did not intervene. The tasks of the facilitating researcher included: explaining the session's goal and the different steps, intervening when ca. 15 to 20 children did not get along, participating in discussions and the making process, ensuring teams stayed focused on the design task, providing additional instructions where needed, etcetera. Whereas teachers are used to this kind of multitasking behavior and know how to give children autonomy within a certain framework of rules and practices, this certainly was not the case for the facilitator leading the co-design sessions.

In summary, we did not expect that many challenges in facilitating teamwork. It felt like, in CCI literature, co-design was not 'advertised' as we experienced it. Especially Druin's guidelines for partnering with children in technology design seemed insufficient at higher child-to-adult ratios (e.g. one facilitator for ca. 15 to 20 children). Working on an equal footage with children in a school context was an arduous task, especially since we had no previous experience at the time and we worked with a varied mix of children. Where our study differs from the research of Druin and colleagues (e.g., Druin, 2002, 1999; Guha et al., 2013, 2005) is that they work with a small selection of highly motivated children in a lab at the university of Maryland on a weekly basis for a prolonged period of time. Moreover, the child-to-adult ratio in their intergenerational design teams is much lower than what we are used to in a school context (see also section *1.6.6.2 Improving children's motivation and collaboration* on pp. 62 in chapter *1. Participatory Design with children*).
From the onset, our goal has been to partner with different types of children (also the less motivated ones) in a more natural environment than a lab context. In public schools, a varied mix of children can be found, which may result in a broader range of ideas for future technologies and practices. Moreover, we argued that working with different types of children may lead to a better and more empathic understanding of children's interests and abilities. In addition, by choosing for a school context, we wanted to teach children how to collaborate in a team and improve their creative abilities.

Based on the challenges encountered in the first three co-design sessions, the question at this point was how to adopt our preliminary co-design procedure in order to better structure collaboration with and among children in a school context. When diving back into CCI literature to look for additional guidelines to facilitate children's collaborative and creative efforts, we did not find satisfying answers. Whereas some authors (e.g., Mazzone et al., 2010; Obrist et al., 2011; Vaajakallio et al., 2010, 2009) provided useful practical tips for how to conduct co-design sessions with children, if at all, group dynamics were discussed rather superficially in CCI literature. Moreover, those who addressed the issue primarily focused on how to overcome Unequal Power dynamics between adults and children (e.g., Druin, 2002; Guha et al., 2013; Mazzone et al., 2010), neglecting challenging group dynamics between children themselves. This gap in knowledge gave rise to the first research question RQ1a (see also chapter *2. Methodology*, pp. 67):

- How can we address challenging intra-group dynamics when co-designing technology with children since these dynamics affect both process (e.g. children's agency) and outcomes?

6.2.4.2 Identifying challenging group dynamics

Addressing RQ1a, we decided to focus more in-depth on challenging group dynamics during the two remaining co-design sessions (i.e., Session 4 and 5). In order to be able to observe the collaboration process more rigorously, we limited the number of children per class group to one team of five children compared to three teams of four to six children in the first three sessions (see Table 1). In consultation with the teachers, we selected five children in each class group based on criteria such as gender, socio-economic background, verbal skills, creative abilities and mathematical reasoning. Our aim was to select the widest possible variety of children within each of the given class groups (cf. purposive sampling). Despite this lower child-to-adult ratio, the way in which we facilitated the sessions did not change considerably compared to the first three sessions.

As for the data analysis using open and axial coding, we considered the observation notes and video footage of the last two sessions together with the reports of the first three sessions to identify the most prevalent challenging group dynamics. In a second iteration, we compared the results with literature on group dynamics in social psychology, because challenging group dynamics had not yet been described in CCI literature. We first looked for an appropriate definition of the concept group dynamics, which we found in the work of Lewin (1948). He was the first to coin the term group dynamics, referring to a system of behaviors and psychological processes that may occur within a social group (intragroup) or between social groups (intergroup). Relying on this definition, we started using the term co-design dynamics to refer to a system of intragroup dynamics occurring within a group of participants who share a common design goal (Van Mechelen et al., 2015b, 2014a).

The data analysis resulted in a list of six challenging intragroup or co-design dynamics:

- Unequal Power: children with a higher status who exert tremendous influence on the group process, either positively or negatively.
- Free Riding: reduced effort by some children in the co-design team, thereby taking advantage of the work of others.
- Laughing Out Loud: an unwillingness to take the task at hand serious as a group resulting in a disruptive atmosphere.
- Dysfunctional Conflict: escalating disagreements about what should be done and how, leading to a polarization within the team.
- Apart Together: team members that work individually instead of fully cooperating and negotiating a design solution.
- Groupthink: poor decision-making by rushing too quickly towards consensus, thereby neglecting valuable choice alternatives.

This list should not be considered as an exhaustive categorization including all possible dynamics. Rather, it is intended to serve as a reflective guide for (inexperienced) design researchers who aim to conduct co-design sessions with children. Whereas some of the dynamics in the list are more exclusively linked to co-designing technology with children, such as Laughing Out Loud and Apart Together, most could be linked to intragroup dynamics described in social psychology, like Free Riding, Unequal Power, Groupthink, and Dysfunctional Conflict.

For a more elaborate description of these challenging intragroup or co-design dynamics, we refer to Van Mechelen and colleagues (Van Mechelen et al., 2015b, 2014a) in chapter *7. Publications research question RQ1a* (pp. 181), and section *9.2 The CoDeT co-design procedure* (pp. 270) in chapter *9. Co-design toolkit*.

6.2.4.3 Analyzing and interpreting co-design outcomes

A few weeks after the last co-design session, preliminary results were presented at Cultuurnet Vlaanderen and used for an in-house brainstorm workshop with educational specialists, developers and copywriters. Despite the participants' enthusiasm, the project was shut down shortly afterwards due to funding cuts. Although this had no consequences for our research, it meant that children's ideas and perspectives would no longer be taken forward to develop a mobile application to learn about arts and culture.

Reflecting on the outcomes of the co-design activities, we could say that the sessions increased our empathy for and understanding of children aged 9 to 10. One reason is the sustained contact we had with children, witnessing their creative endeavors and collaborative efforts. Another reason is the many wonderful suggestions that children had come up with to learn about arts and culture in a playful and engaging way. However, when analyzing the rich and fragmented data resulting from the co-design activities, we faced severe challenges. Since we worked with 103 children in three schools, the amount of data was overwhelming. At the same time, however, children's verbal explanations of the artifacts were rather short and superficial, although we expected these stories to be most insightful. Also, at first sight, many ideas and suggestions did not seem workable in computing terms and were hard to reconcile with educational goals.

We found that the grounded theory based approach as suggested in the Contextmapping procedure (Sleeswijk Visser et al, 2005) did not allow for a systematic and transparent analysis of the data, making our analysis prone to confirmation biases. Although the analysis had

resulted in a broad collection of design ideas, guidelines on how to integrate these different and often contradicting suggestions into a holistic concept were missing. In addition, the results of the grounded theory based analysis had not provided us with deep insights into what genuinely drives and motivates children to learn about arts and culture.
These and other challenges made us question what exactly we were looking for in co-design sessions with children, especially at the early stages of technology design. Was our primary goal to collect user needs, latent or otherwise, and concrete design ideas, or was there another kind of knowledge generation that we might be interested in? And if so, how could we arrive at this knowledge in co-design activities with children? When diving back into literature, we noticed that robust methods to analyze co-design outcomes in a transparent, coherent and profound way were missing. These concerns eventually resulted in the second research question (RQ1b) that would be addressed in the third case study and, retrospectively, in the second one (see also chapter *2. Methodology*, pp. 67):

- How can we interpret co-design outcomes in a transparent and systematic way, incorporating both the visual/tangible and verbal dimensions of co-design outcomes and with the aim to better understand children's values (cf. RQ1b)?

Whereas the first case study was exploratory in nature and led to the formulation of two research questions regarding co-designing technology with children, in the second case study we started looking for answers.

6.3 Case 2: Bullying prevention in primary school

6.3.1 Rationale

The second case study was part of the EMSOC project (Empowerment in a Social Media Culture) that aimed to critically assess the belief that the user is being empowered in a social media culture. As part of the EMSOC project, we focused on child empowerment in the context of bullying prevention. Parallel to the rise of online and mobile media, cyberbullying has become a well-known phenomenon, expanding and intensifying bullying behavior beyond its traditional physical borders. Our goal was to increase self-regulation among 9- to 10-year olds in combatting both traditional forms of bullying and cyberbullying. By empowering the class as a social group, we aimed to revert exclusion due to bullying.
In a series of workshops with experts and teachers, we first identified a set of preconditions to increase children's self-regulation in combatting bullying, and we collected suggestions

for how these preconditions could be created (see Figure 4). Based on these workshops, the design challenge was refined to:

- How can primary school teachers engage children in pro-social behavior, off- and on-line, to strengthen social cohesion in the class group and prevent bullying behavior? What (digital) tools would be useful in this context?

For a state-of-the-art overview on bullying prevention and a description of the results of the workshops with experts and teachers, we refer to Van Mechelen and colleagues (2013). Since the preconditions were based on the expertise of adults only, children were actively involved in the next phase of the research through a series of co-design sessions. During these sessions, children aged 9 to 10 were invited to voice their ideas on how to increase self-regulation in the context of bullying. Children first defined a concrete design problem during a first co-design session, and then worked towards a solution based on their experiences and ideas during a second co-design session.

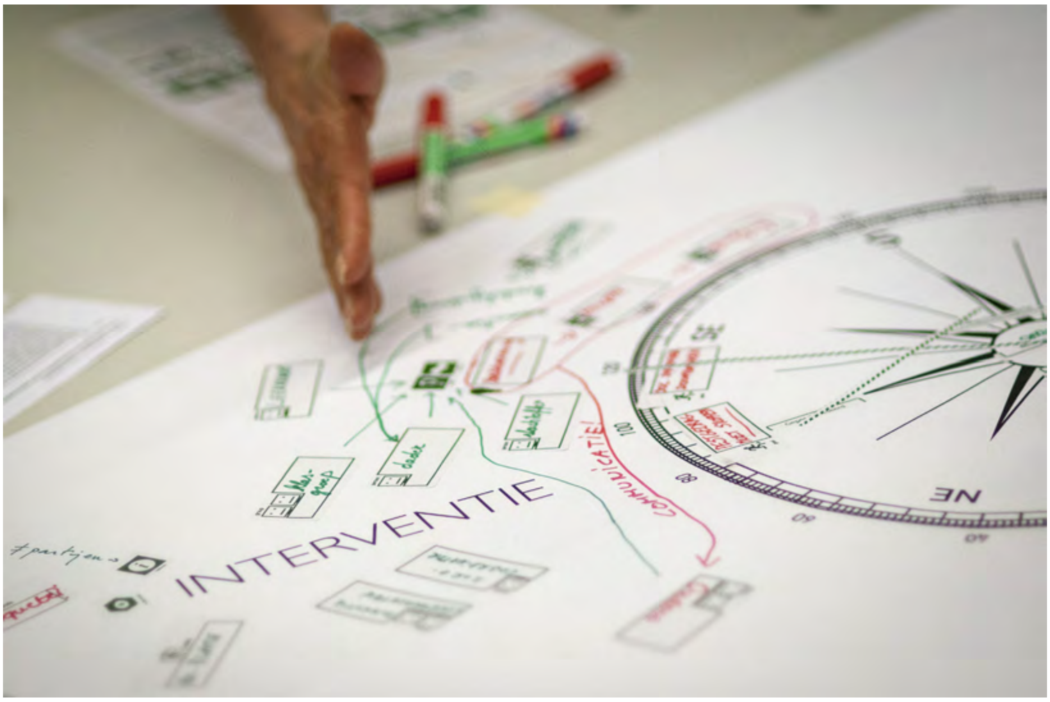

Figure 15: MAP-it workshop with experts and teachers to identify preconditions for increasing children's self-regulation in the prevention of (cyber-) bullying

In what follows, we will explain how we altered the co-design procedure used in the first case study. By relying on Social Interdependence Theory, we aimed to better structure co-operation between children in co-design activities. Both our expectations and our findings with regard to this altered co-design procedure will be described.

6.3.2 Social Interdependence Theory's mediating principles

In this second case study, we looked for ways to anticipate and cope with the challenging intragroup or co-design dynamics, as defined in the first case study. To improve children's creative and collaborative endeavors in co-design activities, especially in scenarios with a high child-to-adult ratio, we mainly borrowed insights from pedagogy and social psychology. We became particularly interested in Cooperating Learning (Dillenbourg, 1999; Johnson et al., 2000; Slavin, 1995) and one of its underlying theoretical foundations, that is Social Interdependence Theory (Johnson and Johnson, 2009, 2005) (see chapter *5. Perspectives on collaboration*, pp. 108). SIT's mediating principles proved to be particularly useful to structure cooperation between children more efficiently, and to improve our preliminary co-design procedure developed as part of the first case study.

Based on SIT, we learned that the manner in which social interdependence between individuals is structured, determines how these individuals interact, which, in turn, determines the outcomes of that situation (Johnson and Johnson, 2009, 2005). According to SIT, social interdependence exists when the outcomes of individuals are affected by each other's actions, either positively, when the actions of individuals promote the achievement of joint goals (i.e., positive interdependence), or negatively, when there is a negative correlation among individuals' goal attainments such as in a competitive situation (i.e., negative interdependence) (Johnson and Johnson, 2009, 2005).
SIT was developed by Deutsch (1962, 1949) and extended by Johnson and Johnson (2005), who identified and validated five principles that mediate the effectiveness of cooperation and competition: positive interdependence, individual accountability, promotive interactions, interpersonal and small-group skills and group processing (for more information, see section *5.3.3.2 Learning Together and Social Interdependence Theory* on pp. 116 in chapter *5. Perspectives on collaboration*). Johnson and Johnson (2005) argued that the combination of these five principles is essential to structure cooperation, which made us wonder whether the principles could also be applied to a co-design setting with children. Questioning this, we relied on SIT to revise our initial co-design procedure. More particularly, by applying the

mediating principles to a design context, we wanted to mitigate or even avoid challenging intragroup or co-design dynamics.

6.3.3 Method

Over a period of one month, we organized two co-design sessions with 49 children aged 9 to 10 in two primary schools in Flanders, Belgium, preceded by a general introduction. This resulted in three visits per schools (see Table 2). The design challenge as presented to the children was:

- What (digital) tools could primary school children use to improve the class atmosphere and thus prevent bullying?

Two researchers were involved in the introduction and each co-design session: one facilitator who interacted with the children and one fly on-the-wall observer making notes. The sessions were recorded on video and a report on the group process was written immediately afterwards. In these reports we focused on the collaboration between children, how they approached the different design tasks and the amount of facilitation that was needed. We paid special attention to the application of the mediating principles and whether children understood what we expected (e.g. with regard to group processing). The general introduction took about 45 minutes per class group, whereas the co-design sessions lasted for about 150 minutes each.

6.3.3.1 Introduction and sensitizing

During the introduction, we explained the reason for our visit. The design challenge was contextualized with a fictional story that reported on a scenario about a class group with a bad atmosphere. The story was told with the intention to increase children's understanding of the problematic situation, and provide them with a clear purpose or end-goal to work towards. For more information about how we introduced ourselves, the project and the story, we refer to Van Mechelen and colleagues (Van Mechelen et al., 2014b). We then introduced a sensitizing package with four individual assignments to trigger children's reflection in a playful and creative way, and to prepare them for the actual co-design sessions. Children worked on these assignments at home in their free time.

	School 1		School 2	
	AM	PM	AM	PM
Session 1	5 boys 7 girls	6 boys 7 girls	6 boys 4 girls	7 boys 7 girls
Session 2	5 boys 7 girls	6 boys 7 girls	6 boys 4 girls	7 boys 7 girls

Table 2. Total amount of participants in case 2: 49 children aged 9 to 10 in 2 schools, divided in morning (AM) and afternoon (PM) groups, and subdivided in 11 teams of 4 to 5 boys and girls

Figure 16 (left): An example of a result of the third sensitizing assignment Class atmosphere; each assignment was put in a sealed envelope to add an element of surprise

Figure 20 (right): Problem definition collages; the yellow sticky notes explain why the corresponding situation is worth solving

The assignments were:

- Self-portrait: children made a self-portrait and drew three things or persons around the portrait and explained why these things/persons are important to them.
- Playing together: children thought of a recent case in which someone could not play with them and explained why that was the case.
- Class atmosphere: children made a drawing of a class with a bad atmosphere. Next they wrote down three reasons why they would not want to be in that class.
- Journalist: children interviewed one of their grandparents about school life and the atmosphere in the class when they had their age.

We collected the results of the sensitizing packages one week before the first co-design session (see Figure 16). A quick analysis of these results provided us with preliminary insights into children's lives and experiences. We also used some of the results as input for the co-design sessions. For instance, children's drawings of a class with a bad atmosphere (third assignment) were used to enrich the fictional story with more concrete examples to increase the story's realism.

6. 3. 3. 2 First co-design session: problem definition

During the first co-design session approximately two weeks after the introduction, the participating children were instructed to define two problems based on their interpretation of the story and design challenge. Each class group was divided in a morning- and afternoon group. With the help of the teacher, these morning- and afternoon groups were split up in two to three heterogeneous teams of four to five boys and girls (see Table 2). We then reiterated the fictional story that we enriched with lively examples of situations causing the bad atmosphere. These examples were based on the data resulting from the sensitizing assignment Class atmosphere. Afterwards, we assigned different roles to each team member. Each role came with a specific responsibility and a tangible badge (see Figure 17), connected to a set of agreements to which we referred to as rules of the game. The different roles and responsibilities were:

- The material guard was responsible for the use of the materials and had to make sure each group member had something (e.g., scissors, glue, etc.) to work with.
- The silence captain had to ensure all team members were quiet when the researcher would give instructions, feedback or help.

Figure 17: Badges with different roles and responsibilities, to be divided among children of the same co-design team

Figure 18: A co-design team presenting their group name The Four Musketeers and logo design

- The responsibility of the inspiration general was to ensure that each child had an equal chance to contribute and that nobody would impose his or her ideas.
- The fourth and last role was that of the timekeeper, who had to prevent the co-design team from running out of time before completing the tasks.

Teams had to think carefully about which role was best suited for which team member and assigned the badges accordingly.

The next phase included an introductory design activity whereby teams had to think of a group name and design a logo (Figure 18), in an attempt to improve the team's cohesion and gain familiarity with the assigned roles in the team. When each team presented their group name and logo, the other teams were invited to express their opinion, so that the participating children would become used to communicating ideas and being evaluated by peers. The following stage entailed an empathy exercise. We handed out the results of the fourth sensitizing assignment for which the children had to interview one of their grandparents about their school life. By discussing how school life had changed since then, we wanted to foster children's creative thinking.

Next, each team received a card with the fictional story, including detailed examples based on the results of the fourth sensitizing assignment (see Figure 19). The design challenge embedded in the story was deliberately kept broad, because we wanted each team to redefine the design challenge based on their interpretation of the story. We hoped that this would increase feelings of problem ownership, as suggested in Thoring and Muller's (2011) Design Thinking model (see chapter *4. Design Thinking in co-design*, pp. 95). The teams were asked to make a collage on a big sheet of paper that would illustrate the negative class atmosphere in the story. They could use different materials, but to encourage children discussing their approach with their team members, we limited some of the materials to only one piece per team (e.g. scissors and glue stick).

Children were then asked to write down why each of the situations they had just visualized negatively influenced the class atmosphere (see Figure 20). This idea of gaining insights into children's underlying motives by probing for why-questions, was borrowed from the UX Laddering approach (see chapter *3. How values can serve technology design*, pp. 79). As a first convergence phase, they then had to pick two problematic situations for which they would invent a solution during the next co-design session. Afterwards, each team briefly presented the collage and the two problems they had selected to the other groups.

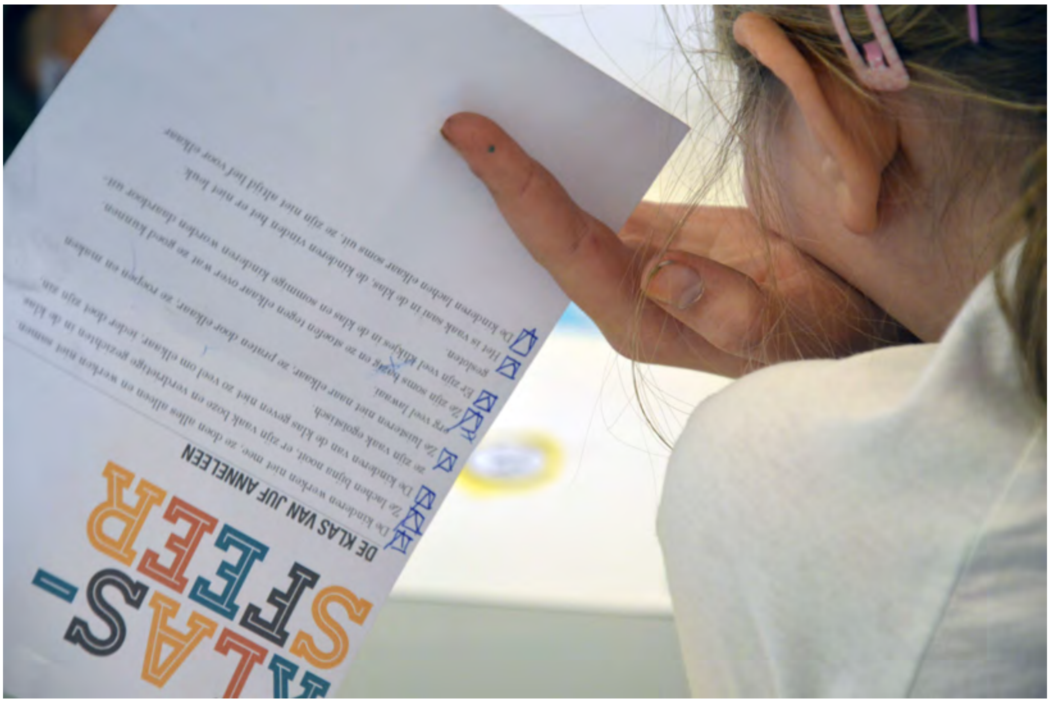

Figure 19: Girl holding a card with a fictional story illustrating the design challenge to be addressed during the co-design activities

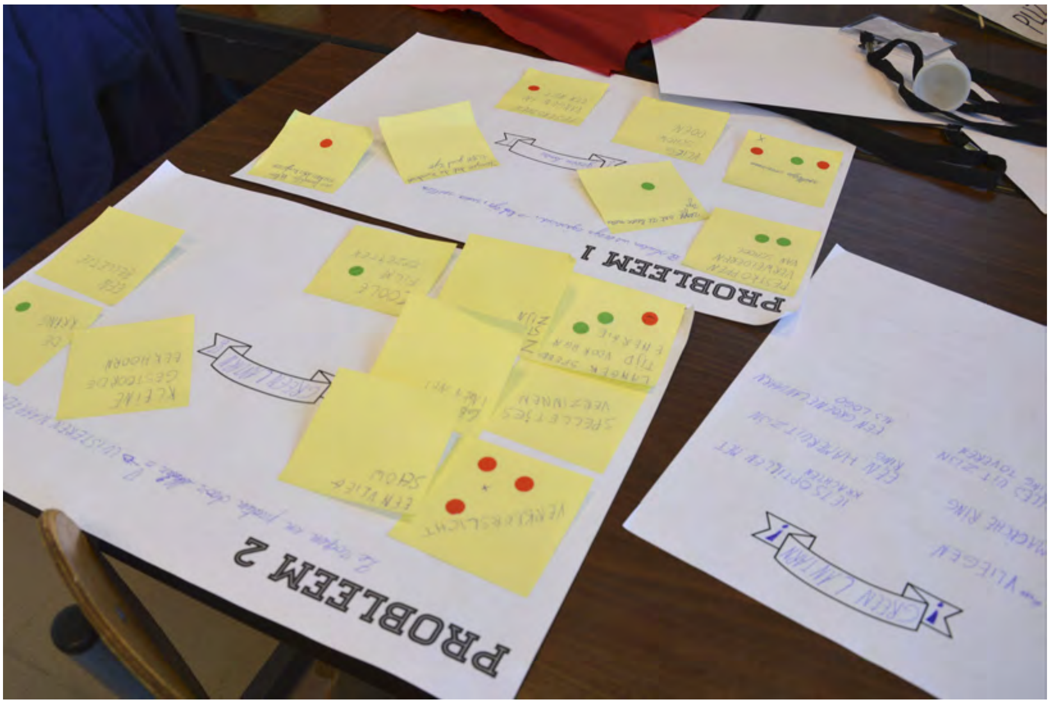

Figure 21: Ideation sheets with different ideas on sticky notes; each co-design team selected two ideas for further elaboration through sticky dot voting

At the end of the co-design session, we asked the teams to evaluate the collaboration process. Each team was asked to think of three actions that were considered helpful to accomplish the team's goals, and one action that could be added or changed to make the team even more successful during the next co-design session. Finally, we briefly explained what would happen during the next session that was scheduled approximately one week from then.

6. 3. 3. 3 Second co-design session: problem solving

The goal of the second co-design session was to design a solution for the problems defined in the first session. To refresh children's memory, we handed out the collages that came out of the first session. We encouraged the teams to reallocate the roles by discussing which role was best suited for whom. We hoped that the group processing at the end of the previous session would help them to make more thoughtful decisions compared to the first session.

We then introduced the brainstorming exercise in which the teams were instructed to consider different ideas to solve the two problematic situations (divergence). Each team member could write down any new idea on a separate sticky note and put it in the middle of the table so that team members would inspire each other. After brainstorming ideas, we asked the teams to group similar ideas together and to select two ideas for further elaboration (convergence). The selected ideas were then used as a source of inspiration to prototype tools that would improve the class atmosphere and prevent bullying (see Figure 21). During prototyping though, children were again encouraged to consider new or additional ideas and perspectives they had not yet thought of (divergence). The material guard of each team received a bag with all kinds of prototyping materials (e.g., scissors, cardboard, glue, aluminum dishes, ropes, etc.). Just as in the previous session, we limited some of the materials to one piece per team (see Figure 22 and 23).

The prototyping activity ended with a presentation about the team's designs (see Figure 24). Each team was instructed to either explain how their solution would improve the class atmosphere or organize a small performance. When one team was presenting, the other teams functioned as a jury who could voice critical, but constructive questions and opinions. Before moving on to the next presentation, we asked each jury member to fill in a form with questions such as: "What do you like about the team's invention to improve the class atmosphere?", "Why do you like it?", "If there is one thing you could change, what would be it?" and "Why would you like to change it?" (see Figure 25). These questions were inspired by

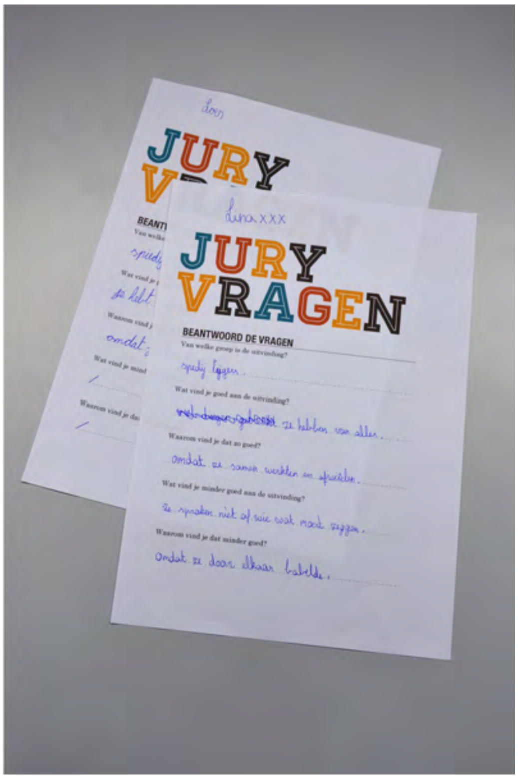

Figure 22 (left): Each co-design team received a bag with low-tech prototyping materials to build a scaled model of their design solution
Figure 25 (right): Examples of completed peer jury forms in which children explain what they like and dislike about the designs of other co-design teams

the UX Laddering procedure (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010) because of the technique's typical why-probing.

At the end of the session, teams were once more asked to evaluate the group process, so as to improve their future collaborative efforts. Finally, a short wrap-up followed in which we explained how we would use their ideas and suggestions to inform and inspire the further design process.

6.3.4 Expectations

By applying SIT's mediating principles, we aimed to better anticipate and remediate potential challenging intragroup or co-design dynamics. These principles were implemented in a number of ways in the two co-design sessions.

We implemented positive interdependence in three ways as suggested by Johnson and Johnson (2009, 2005). Firstly, we structured outcome interdependence by providing

children with detailed context information and a clear end-goal. To this end, a storytelling approach was used to frame the different co-design activities. The co-design teams were instructed to define two problems based on their interpretation of the story and the design challenge embedded in it, in order to create a sense of problem ownership and task cohesion and avoid a lack of interest and the Laughing Out Loud phenomenon.
Secondly, we structured boundary interdependence by separating groups into space so each team had their own spatial working spot. We furthermore initiated an introductory design activity in which teams had to think of a group name and design a logo, which they then presented to the other teams. We expected that this would improve the team spirit and children's commitment towards each other (cf. social cohesion). In the previous case study we experienced that not all children were happy when we first divided them into heterogeneous teams, because they wanted to be in the same team as their friends. In some cases, this led to the Apart Together phenomenon, but we aspired that by putting enough effort in team building activities this challenging dynamic could be mitigated or even avoided.

Thirdly, we structured means interdependence by giving each child a distinctive role in the team and by limiting some of the materials that children could use. It was expected that the use of roles would increase feelings of responsibility. Although we played with the idea to use more conceptual roles that would foster creative thinking (e.g. risk taker), we eventually chose for rather practical roles as is usually the case in Cooperative Learning settings (e.g. timekeeper, material guard).
In line with a positive or authoritative parenting style (Baumrind, 1967; Santrock, 2007), we linked these roles to a set of boundaries or rules. Whereas we encouraged children to be independent and make their own choices in negotiation with their team members, we simultaneously placed limits on some of their actions and asked for a certain degree of maturity. This way, we created a framework within which children could move freely, so as to avoid that one child's freedom would easily become another child's lack thereof. Children were asked to encourage fellow team members and stick with their team, to pay attention to instructions given by the facilitator, and to take care of the materials. In the first case study we noticed that clarifying our expectations with regard to children's behavior was vital, especially in a school context where children are not used to having full autonomy.
At the same time, however, we wanted children to take initiative and be creative, so we were not too rigid about these rules and avoided a punitive or authoritarian approach. Therefore, we framed our expectations in a positive manner as rules of the game. In addition, we hoped that aiming for heterogeneous team composition based on skills and abilities, and limiting

Figure 23: A co-design team engaged in low-tech prototyping activities during the elaboration through making phase

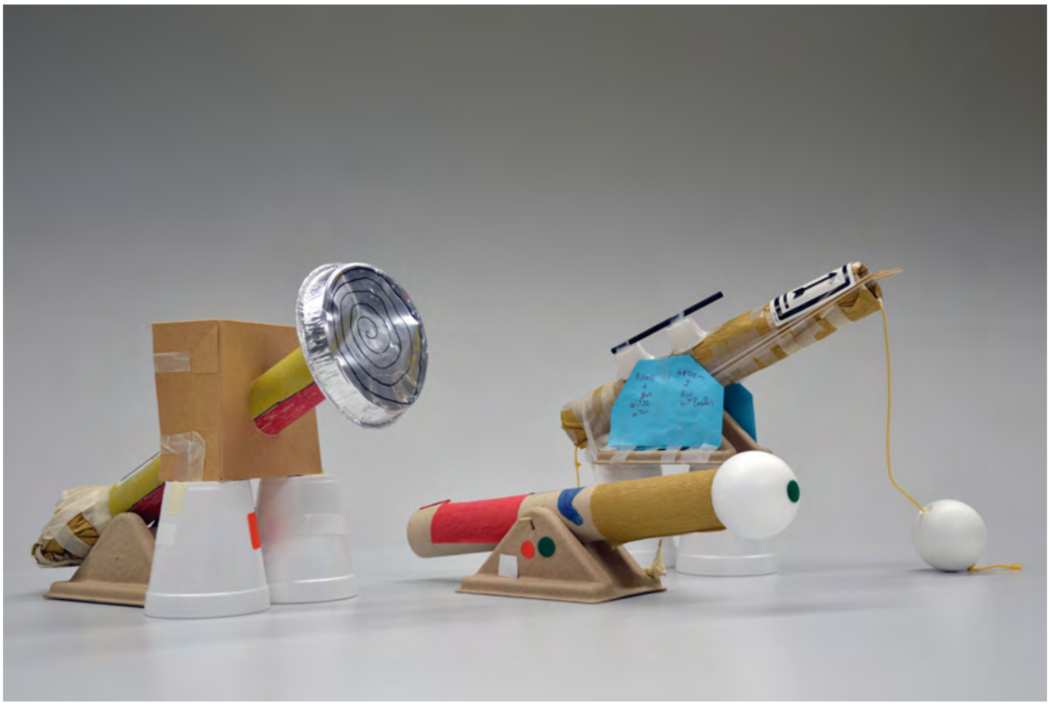

Figure 24: Design solutions for combatting (cyber-) bullying resulting from the co-design activities

the amount of materials would encourage children to discuss their approach. We aspired that, by structuring means interdependence, we could prevent the Free Riding dynamic.

It took us some time in order to figure out how to implement the second mediating principle, individual accountability. In a collaborative learning setting, children are typically assessed on an individual and group level. Our concern was that individual assessments would be perceived as too school-like, hampering children's creative abilities, and, therefore, we did not formally evaluate children's efforts. Rather, we hoped that the use of the roles in itself would be sufficient to increase feelings of responsibility towards the team. In an attempt to foster feelings of group accountability, we furthermore implemented a peer jury at the end of each session so that the team as a whole was evaluated by other teams.
As for the third principle, promotive interactions, we assumed that this was primarily a task for the facilitator during the sessions, and not so much something that we could implement in our procedure. By participating in discussions and facilitating turn taking and active listening, we aimed to exert a positive influence on the quality of the interactions. In addition, by improving children's social skills (see next principle) and structuring positive interdependence, we hoped to exert indirect influence on the amount of promotive interactions as well.
Improving children's social skills, the fourth mediating principles, was another difficult issue. Whereas teachers can make this into a long-term project throughout the school year, our time schedule was rather tight. Nevertheless, we tried to improve children's interpersonal and small-group skills by gradually increasing the complexity of the cooperative efforts and by specifying what kind of interactions they should be engaged in while facilitating the activities (e.g. active listening, providing arguments). Additionally, we assumed that children's social skills as well as their motivation to use these skills would improve towards the second session by implementing group processing.

Group processing, the fifth mediating principle, was implemented as a separate phase at the end of each co-design session. During group processing, team members discussed their collaborative efforts, that is, how well they were achieving their goals and maintained effective working relationships. We reasoned that this would improve their collaborative and creative endeavors in the next co-design session or any other teamwork setting. Also, we hoped that group processing and improved interpersonal and small-group skills would diffuse tension build-up, and prevent Dysfunctional Conflicts.

6.3.5 Findings and observations

Applying SIT's five mediating principles to our co-design procedure was no magical formula, since we could not completely avoid challenging intragroup or co-design dynamics between children. However, we noticed important improvements in children's collaborative efforts, and SIT's mediating principles helped us to more thoughtfully prepare the co-design activities.

As for the storytelling approach to implement outcome interdependence, we found that children sympathized with the story's lively examples based on the data of the sensitizing assignment Class atmosphere. The story and design challenge provided focus throughout the different co-design activities and were easily remembered, as was demonstrated by some children who spontaneously reiterated the story. We also noticed that many children were fully committed to invent something to solve the problems they had defined based on their interpretation of the story, which may point towards feelings of problem ownership and task cohesion. This was not always the case in the first study in which we defined the problem top-down, and in which we did not yet add this separate convergence phase as suggested in Thoring and Müller's Design Thinking model (Thoring and Müller, 2011). By involving children in problem definition, we noticed that they did not get caught up in an unserious atmosphere (Laughing Out Loud phenomenon) that easily.

Although not all children were happy when we first divided them into heterogeneous groups, the introductory teambuilding activities in which they designed a logo were often effective in reversing feelings of disappointment. Although not all teams collaborated equally successful, we noticed progressions in children's commitment towards the team, indicating improved social cohesion. As for our intention to give each team a separate work spot, practical constraints oftentimes stood in our way. In most schools, all teams had to be seated in a rather small room, which led to an exchange of ideas across teams (e.g. all teams building a robot, be it with different functionalities attached to it). Despite these constraints, the Apart Together phenomenon was only marginally present, although we did notice some cases of gender-based favoritism within teams.

With regard to structuring means interdependence, in the first session we noticed that role division led to disagreements. Probably because we had not emphasized that team members had to discuss which role was best suited for which team member. We furthermore noticed that the responsibility that came with each of these roles was not always clear. As a workaround, in the second session, we provided better instructions and summarized the responsibilities for each role on a badge that children had to wear. We also provided active

tasks for each role throughout the session, for instance timekeepers had to set an alarm clock, and material guards received a bag with prototyping material. This seemed to help children to better execute their role, resulting in less cases of Free Riding. When Free Riding nevertheless occurred, we found out that the roles were a useful tool to gently point children towards their responsibility.
As for limiting the amount of materials that teams could use, we noticed that this did not always enhance communication between children about how to approach the design task, and sometimes even led to process conflicts (e.g. about who could use the pair of scissors). At first, we gave extra materials to solve such disputes, until we noticed that this did not enhance children's collaborative efforts either. Therefore, in later stages, we encouraged children to negotiate a solution themselves, which resulted in more constructive dialogues and, at first sight, in better interpersonal and small-group skills.

The peer jury approach in which teams presented their designs to the other teams who then asked questions or gave constructive feedback, was found to be an effective strategy to create a sense of group accountability in the teams. We noticed that even the boldest children wanted to make a good impression in front of their peers when presenting their ideas. As for the written jury form, our results showed that the why questions that were inspired by the UX Laddering procedure (Zaman and Vanden Abeele, 2010; Vanden Abeele et al, 2011) were difficult for some children. Nevertheless, the results also suggested that this additional step of a written form resulted in a more substantive discussion about the design as compared to the first case study.
This probing into children's underlying motives was also applied in other design phases, such as the problem definition phase. Children had to write down why they believed the problems they had defined were worth solving, which encouraged reflection and discussion among team members too.
At the start of the co-design activities, it was clear that in none of the schools children were accustomed to working in a team. As a consequence, we observed many contrient interactions during the first co-design session, such as children following their idiosyncratic interests without consulting fellow team members. Here, our role as facilitator as well as the group processing phase proved to be vital. Most teams succeeded in applying their suggestions for improvement agreed upon during group processing throughout the second co-design session. This eventually resulted in more promotive interactions, for instance in how children dealt with disagreements and how they negotiated roles and divided tasks among each other. To our knowledge, these promotive interactions were a clear indication that

children's interpersonal and small-group skills as well as their motivation to use these skills had improved over time.
The group processing phase that we installed at the end of each co-design session was not without problems. First, children blamed each other for things that went wrong, which in some cases led to further escalations within the team. We responded to this by altering the group processing procedure. Personal attacks were no longer allowed and teams now had to list three actions that were helpful and one action that could be added or improved for the whole team. In addition, we better explained the purpose of group processing: that the goal is not to evaluate peers but to improve collaboration over time. This clearly led to more constructive discussions between team members about their collaborative and creative endeavors. Interestingly, children spontaneously referred to the roles during group processing. Apparently, this made the criticism less personal and easier to digest.

To sum up, SIT's mediating principles were a useful tool to structure cooperation between children more thoughtfully. Not only did SIT help us to prepare the co-design activities, the theory also provided valuable insights to cope with challenging intragroup or co-design dynamics. Throughout this second case study, we realized that managing challenging group dynamics is often a question of finding the right balance, rather than attempting to completely prevent or eliminate them. Oftentimes, we noticed that these dynamics are interrelated. For instance, cohesive teams were usually more prone to Groupthink, whereas teams that lacked social cohesion benefited most from team building activities and the use of roles to prevent the Free Riding and Apart Together dynamic. Whether or not children were able to transform these challenges themselves depended on many factors, including the school culture and children's previous experiences with teamwork. Therefore, when we noticed that one of these dynamics was too strongly presented and had a severe impact on children's collaborative efforts, we intervened with SIT's mediating principles in mind.
For a more detailed description of how we implemented SIT's mediating principles and with what results, we refer to Van Mechelen and colleagues (2015b) in chapter *8. Publications research question RQ1b* (pp. 227), and section *9.3 The GLID analysis method* (pp. 286) in chapter *9. Co-design toolkit*.

6.4 Case 3: Towards child-friendly Terms of Use

6.4.1 Rationale

As part of the EMSOC project we conducted another, yet smaller case study that was set up with the goal to increase the child-friendliness of the Terms of Use of websites for children, including criteria of transparency and comprehensibility. Terms of use are the contract users have to agree to when they create online accounts, social media profiles or when downloading applications. They are the traditional way of providing users with information so they can make informed decisions regarding these services. Agreeing to the terms of use of online services establishes certain rights and obligations that both users and the online service provider have to respect. Therefore, the way users behave on these online services can have legal consequences. The project would address a well-known problem with Terms of Use, that is that people, let alone children, do not read them carefully or do not fully understand its content, nor its consequences (Wauters et al., 2014).

In what follows, we will first elaborate on the co-design procedure, which was a simplified version of the procedure used in the first and second case study due to time constraints. In this case study, we focus in particular on the analysis of the co-design outcomes, which eventually resulted in the development of the GLID method.

6.4.2 Method

6.4.2.1 The co-design procedure

Together with the Flemish public broadcaster Ketnet (see Figure 26), who offers a television channel and website for minus 12-year-olds, we set up a series of co-design sessions to give children and their parents a voice in redesigning the Terms of Use of Ketnet's website (see Figure 27). Over a period of two weeks, two co-design sessions were organized in the Design Room of the Centre for User Experience Research (CUO, KU Leuven - iMinds). In each session 8 children aged 8 to 10 and 8 of their parents participated, for a total of 32 participants (see Table 3). After a short introduction, children were put together in a team, and parents in another team. Both teams worked separately and in parallel on the same assignment.

	Session 1	Session 2
Children	3 boys 5 girls	4 boys 4 girls
Parents	6 mothers 2 fathers	5 mothers 3 fathers

Table 3: Total amount of participants in case 3: 32 of which 16 children aged 9 to 10 and 16 parents, divided in two groups (session 1 and 2), and subdivided in teams of 8 children and 8 parents

The design challenge was:

- How can we make Ketnet's Terms of Use more child-friendly in order for these Terms of Use to better resonate with children's lives and be more meaningful to both children and parents?

Three researchers were involved in each co-design session: two facilitators, one for the children and one for the parents, and a fly-on-the-wall observer making notes. The presentation and discussion at the end of each co-design session were recorded on video and a report was written immediately afterwards. Each session lasted for three and a half hours and consisted of the following phases:

- Sensitizing
- Introduction and warm-up
- Ideation and selection
- Elaboration through making
- Presentation and discussion

Just as in the previous case studies, sensitizing was used to trigger the participants' reflection in a playful and creative way before the actual co-design session. We introduced the assignment approximately one week before the session via e-mail. Participants, both children and parents, were asked to map activities they did together during the past week on a continuum ranging from not so fun to super fun. They could either write it down or draw the activity on the continuum.

Besides triggering reflection, the sensitizing assignment was also used as an icebreaker at the start of the co-design sessions. Moreover, because none of the children or parents had met each other before, we initiated a discussion about the completed assignment that the participants had brought to the session as a way to get to know each other. During the introduction, we also introduced the design challenge, which we had translated in a more child-friendly language:

- What tips would you give to other children about what is allowed and what not on the Ketnet website; what kind of behavior should children be engaged in to make it a safe environment?

Next, the team of children and the team of parents moved to a different room so they would not influence each other. In each team, we initiated a discussion about the participants' online media use and interests. We then explained the rules of the game for the co-design session: "listen to each other", "there are no bad ideas" and "stick to your team". This time, we did not make use of separate roles and responsibilities because we assumed that this might take too much time.

For ideation, we relied on the extreme characters approach to foster imagination (Jansen et al., 2013). Each team was provided with three extreme characters that we had been prepared in advance. These extreme characters were drawn on a sheet of paper with the following three scenarios of a child in his/her bedroom: 1) a bully with a catapult who likes to play violent games, 2) a nerdy looking kid with an iPod interested in archaeology and a fan of Star Wars, 3) a girl whose favorite color is pink and who loves horse riding. The sheet of paper also included a list of online activities these children often engage in, such as uploading a selfie, liking a friend's post, modifying a profile, adding friends, posting a comment.

Each team was asked to think of tips or suggestions on how these fictitious characters should behave on the Ketnet website to make it a safe environment. During brainstorming, we encouraged them to build on each other's ideas and not to think about the quality of the ideas yet. Based on the brainstorm outcomes, teams were instructed to group similar ideas together and to anonymously and individually vote for favorite ideas. In each team, we asked to consider the ten most popular tips and visualize these selected ideas on a big sheet of paper (see Figure 28). Teams were free to choose how to approach the task (e.g. visualizing the tips, designing an interface, illustrating the tips with concrete examples).

Figure 26: Screenshot of the Ketnet website for minus 12-year-olds

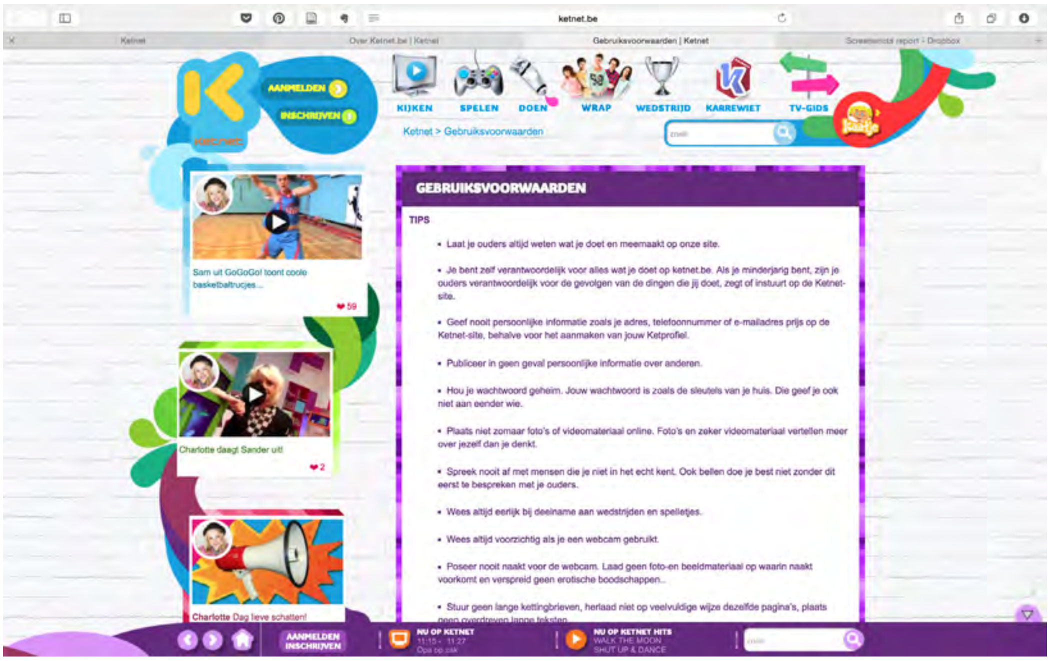

Figure 27: Screenshot of the Terms of Use of the Ketnet website

At the end of the session, teams were asked to present their top ten to each other and in front of the camera. The team that was not presenting functioned as a jury and could ask critical, but constructive questions (see Figure 29). We moderated this discussion between children and adults, and asked some open-ended questions ourselves, such as: “Can you give a concrete example of how and when a child should apply this tip?”, “How can parents and Ketnet help children to get to know this tip?”, “Why is this tip so important for you?”, et cetera. The session ended with a short wrap-up in which we explained the next steps of our research, and each child received a small gift.

	CONTENT Child as receiver (of mass productions)	CONTACT Child as participant (adult-initiated activity)	CONDUCT Child as actor (perpetrator / victim)
AGRESSIVE	Violent / gory content	Harassment, stalking	Bullying, hostile peer activity
SEXUAL	Pornographic content	Grooming, sexual abuse on meeting strangers	Sexual harassment, sexting
VALUES	Racist / hateful content	Ideological persuasion	Potentially harmful user-generated content
COMMERCIAL	Embedded marketing	Personal data misuse	Gambling, copyright infringement

Figure 30: The 3C’s model for classifying online risks as proposed by Livingstone et al (2011)

6. 4. 2. 2 Analyzing the co-design outcomes: The three C’s model

We qualitatively analyzed the data consisting of various elements of the co-design sessions: the teams’ visualizations, verbal transcripts of the presentations and discussions, reports written after the sessions based on our observation notes, and video footage.

The preparation of the data analysis started with an expert review of Ketnet’s Terms of Use that we, as user experience researchers, performed collaboratively with a media scholar, and a legal expert. We thereby thematically categorized the content addressed explicitly in the Terms of Use. Then, we transcribed the presentations and discussions that were held at the end of the co-design sessions, and which had been recorded on video. We further considered all the sessions’ materials, including the initial ideas and visualizations, to contextualize and better understand the final outcomes of each team.

Figure 28: children (left) and parents (right) engaged in ideation and making activities

Figure 29: A team of parents presenting their top ten tips for child friendly and transparent Terms of Use to a team of children)

During the further data analysis, we classified the tips and suggestions from children and parents according to the EU Kids Online model for the classification of online risks, also known as the 3C's model (see Figure 30) (Livingstone et al., 2011). This model classifies online risks into three main categories:

- Content: here the child is positioned as recipient of mass produced content
- Contact: the child is viewed as participant in adult-initiated activities, if unwillingly
- Conduct: the child is perceived as having an active role either as perpetrator or as victim in peer-to-peer exchanges (i.e. child as actor)

The data allowed us to flesh out each of these categories, which were further divided into four subcategories, namely: aggressive, sexual, values and commercial. In order to conduct a comparative analysis, we then mapped the current content of the Terms of Use of the Ketnet website on the 3C's model as well. Finally, we summarized our findings and formulated a well-founded advice for Ketnet in the form of a list of requirements for child-friendly terms of use.

6.4.3 Expectations

With regard to the co-design procedure, which was a simplified version of the procedure used in the first and second case study, we maintained the consecutive steps of divergence and convergence as suggested in Thoring and Muller's (2011) model to scaffold participants' creative thinking and problem solving capabilities. Just as in the previous studies, we introduced a sensitizing assignment before the co-design session to activate reflection on the design challenge. However, we did not implement the five mediating principles as suggested in SIT to structure collaboration between the participants because of practical time constraints.
For the same reason, we were not able to devote the same amount of time to introductory design and teambuilding activities as in the previous study. We organized only one instead of two co-design sessions, and we did not allocate different roles and responsibilities. Since the amount of participants per session was limited compared to the previous studies, we assumed that we would be able to intervene adequately if the group process would falter due to challenging intragroup or co-design dynamics.

As for the analysis of the data, our goal was to move beyond the surface level of the concrete ideas and suggestions that children and parents would come up with, and to initiate a dialogue about their underlying reasons and motives for these ideas and suggestions.

Moreover, we assumed that our template approach based on the 3C's model (Livingstone et al., 2011) would help us to show relations and differences in the views of the different stakeholder groups that were involved in the study, namely Ketnet, children and parents. By following a stepwise procedure in which both the visual and textual material, and the initial ideas and final outcomes would be taken into account, we aimed to arrive at a more holistic and empathic understanding of the three stakeholder groups.

6.4.4 Findings and observations

Compared to the previous case studies, the co-design setting was quite different. The activities did not take place in children's school, but in the Design Room at our university during the weekend. In addition, parents were involved in this study, and although children and parents worked in separate teams, we noticed that some children behaved in a socially desirable way during the introduction and presentation. Some parents took up the role of the 'all knowing adult' while presenting their tips and suggestions for child-friendlier Terms of Use, trying to educate their children about how to behave online. Clearly, this complex dynamic between children's social desirable behavior and parents' pedantic attitude was something that we had underestimated. By probing into the reasons why children and parents suggested certain tips during the presentations, we were nevertheless able to reveal interesting insights.
Challenging intragroup or co-design dynamics between children occurred as well. Especially the Free Riding and Laughing Out Loud dynamics were frequently observed. Due to the lower child-to-adult ratio (two adult researchers for a team of six children) we could intervene right away. Our knowledge about challenging group dynamics and SIT's mediating principles helped us to react adequately, preventing these dynamics to become too strong. This finding reinforced previous experiences about SIT's usefulness in co-design activities with children. Even when the mediating principles are not formally implemented, the theory remains useful, especially in combination with the list of challenging intragroup dynamics.

With regard to the analysis of the co-design outcomes, we soon noticed that we had to alter our template approach. The 3C's model as proposed in the EU Kids Online study provides four subcategories (i.e., aggressive, sexual, values and commercial) for each of the main categories Content, Contact, and Conduct (Livingstone et al., 2011). For the sake of our analysis, we had to add the additional subcategory other because some of the tips mentioned by the participants did not properly fit in any of the risk subcategories (e.g. "Play outdoor more often; there is more out there than just the internet"). In some cases, we could classify the same tip under different risk cells. For instance, the tip "Don`t lie about your age when signing up for an SNS" proposed by a team of children was associated to the risk of potentially inappropriate content, as well as to the risk of being contacted by (adult) strangers.

After classifying the tips from children and adults expressed during the co-design activities, and the current content of the Terms of Use of the Ketnet website along the 3C's model, we conducted a comparative analysis. To arrive at a nuanced understanding, we grounded the tips and suggestions from children and adults with all the sessions' materials. The results showed that those responsible for the Ketnet website, parents and children did not always perceive the same (or very similar) behavior as leading to the same potential online risks, indicating different views and perhaps even conflicting values. However, despite these differences, interesting and complementary elements could still be recognized.

For instance, from the tips elaborated by children one of the main conclusions is that they recognize themselves as active users of the platform. As such, they feel the need to teach other children to behave responsibly on the website. Parents, on their turn, emphasized protecting their children from third-party (e.g. commercial content) and adult threats (e.g. grooming). They somehow seemed to have a view of children as vulnerable individuals, not yet fully aware of the dangers that the internet offers and, therefore, also not fully capable of coping on their own with these risks. They expected, therefore, that Ketnet not only provides tools to educate children regarding online risks and how to best tackle them, but they also expected the service provider to offer a platform which is extremely safe by design. This view was reflected in the protective and preventive character of the tips they devised.

As opposed to parents and children`s views, the service provider seemed to struggle in finding the right balance between educating children to behave responsibly and safely on the Ketnet website, and trying to make clear to users what their (legal) rights and obligations on the website were. However, based on this comparative analysis, we were able to formulate a well-grounded advice to make the Terms of Use of the Ketnet website more meaningful and engaging for children (for a detailed description of the results and recommendations, we refer to Donoso, Van Mechelen and Verdoodt (2014).

In conclusion, although the semi-structured template approach sometimes felt as a forced fit, it nevertheless helped us to compare the views of the different stakeholders in a more systematic way, and on a more abstract level, making underlying tensions explicit. When analyzing the transcripts of the presentations, we found out that contextualizing participants' verbal explanation with all of the session's materials (e.g. initial vs. selected ideas) led to a more nuanced understanding. We also noticed that the visual dimensions of the co-designed

artifacts could tell a great deal about how the participants interpreted the design challenge (e.g. colorful interface vs. strict rules visualized with concrete examples).
These findings inspired us to develop an interpretative approach to analyze co-design outcomes, looking at both the visual/tangible and verbal dimensions and with the aim to better understand children's underlying values (cf. research question RQ1b). In contrast to the template approach used in this case study, we aimed for a more deductive, bottom-up oriented approach. In the next section we discuss the development of this method and how we retrospectively applied it to the results of the second case study.

6.4.5 Developing the GLID method

6.4.5.1 Lessons from previous experiences and literature

In the first case study, we struggled with analyzing the outcomes of the co-design sessions, which resulted in our second research question. Similarly, in the second case study, the amount of data was overwhelming and, at first sight, some ideas were not very realistic or were hard to reconcile with educational goals. In addition, some teams proposed contradicting design ideas that we found hard to reconcile. Combining this multitude of ideas into a holistic design is challenging. Again, this raised the question about how to analyze the co-design outcomes beyond the surface level of children's ideas (cf. research question RQ1b). Therefore, in the third case, we focused more in-depth on the analysis of co-design outcomes as described in the previous section, but so far with mixed results. As a first step to develop a more interpretative approach, we carried out an additional literature review and identified two tendencies that we thought were problematic (see also section *1.6.6.1 Analyzing and interpreting children's contributions* on pp. 60 in chapter *1. Participatory Design with children*).
First of all, we noticed that co-design artifacts are often regarded as a neutral means to access children's perspectives. Hence, design researchers often limit themselves to a what participants say or write about their creations (e.g., Sanders, 1999; Sleeswijk Visser et al., 2005; Stappers and Sanders, 2003). However, in the study described in the previous section, we had experienced that interpreting the verbal explanation in relation to the visual dimensions of co-design artifacts resulted in a richer, more contextual understanding of these data, especially when also the process from initial ideas to outcomes is being accounted for in the analysis.

Secondly, we noticed that some authors stick to a descriptive or functional analysis of co-design outcomes (e.g., Druin, 2002; Guha et al., 2004; Mazzone et al., 2008; Read et al., 2014; Walsh et al., 2010), whereas others take a more interpretative stance (e.g., Gielen 2007; 2008; Van Doorn et al, 2013; Iversen et al, 2010; Frauenberger et al, 2012). Approaches within the latter category aim to identify children's underlying rationales or motives behind certain design choices. In a similar fashion, we argue that, in addition to generating innovative and useful ideas, co-design can result in a rich and empathic understanding of children. It is at this point that we became interested in the concept of values.

Our main motivation to look into the concept values was that PD, from its very beginnings, has been a highly values-led design approach that has concerned itself with values of democracy, empowerment and empathy (Frauenberger et al., 2015). Co-design and other generative techniques are used in PD practices to establish a process of mutual learning between designers, users and other relevant stakeholders. This process of mutual learning is seen as strongly situated and mediated by the values that co-design participants bring to the table. Throughout a co-design process, these stakeholders share decision-making power and co-construct future technologies and practices. However, in more pragmatic PD practices that have gained in popularity in recent years, this focus on sharing decision-making power and negotiating values became of secondary importance. In pragmatic approaches to PD, co-design techniques are often downgraded to an efficient way for developing user-friendly and commercially viable products.

In a response to this and in an attempt to turn to PD's original value-agenda, we became interested in a stronger theoretical foundation to engage with values than what was currently available in literature on generative techniques such as co-design. For this reason, we did an extensive literature review on approaches in HCI that have concerned themselves with values. Especially the discourse surrounding Value Sensitive Design (Friedman, 1996; Friedman et al., 2006), and the UX Laddering approach (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010) that relies on Means-end Theory (Gutman, 1982; Reynolds and Gutman, 1988) proved insightful (see chapter *3. How values can serve technology design*, pp. 79).

6. 4. 5. 2 In search for a theoretical foundation

Based on our notion of values, as extensively described in chapter *3. How values can serve technology design* (pp. 79), we did not consider it useful to first identify children's values and than design for them, but instead we advocate an approach of reconsidering values

throughout the design process. We argued that one way to arrive at such a situated understanding of values is by involving children in co-design activities. We believe that by collaboratively exploring a problematic situation, both the values at stake and the design problem develop, ultimately to be grounded in the co-constructed artifact.
However, children rarely negotiate values explicitly in co-design activities. This may be due to their abstract and meta-cognitive thinking skills that are only beginning to develop. Since values are critical motivators for attitudes and behavior, co-design outcomes nevertheless tell us something about children's values, be it implicitly. To arrive at these values resulting from a collective sensemaking process, we looked for a suitable, interpretative method which we could not find in literature on co-design techniques.
To address this gap in research we developed a new method for which we borrowed from different approaches and theories. One approach that seemed particularly useful for this matter was UX Laddering (Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010). Although the method was developed to evaluate prototypes or finished products with children, the Means-end Theory that forms the backbone of the method offered interesting possibilities to link children's suggestions in co-design activities to their underlying and negotiated values.
The theory makes a distinction between a product or prototype's functional design attributes, the perceived benefits or consequences of these attributes and how these relate to a user's underlying values (Gutman, 1982; Reynolds and Gutman, 1988). We argued that making these linkages explicit could be used in a similar fashion when analyzing co-design artifacts. This would not only make our analysis more transparent, because the values could be traced back to the artifact's functionalities, but it could also lead to a more situated understanding of these values.

What was still missing at this point was a theoretical foundation to bring together the verbal explanation and the visual dimensions of the co-design artifacts in a coherent analysis. For this matter, we relied on a social semiotic approach to multimodality. Multimodality is a theoretically grounded approach based on the premise that communication always includes several different modes that contribute to the meaning of a message (Kress, 2010). Each of these modes has different affordances that make them suitable for communicating specific information (Jewitt, 2010). We argued that various co-design outcomes, such as children's verbal explanation and the artifacts they create, could be seen as different modes contributing to a central message. From a multimodal perspective, it is therefore crucial to analyze the combination of these different modes of communication, which information they communicate, and how they complement each other.

6. 4. 5. 3 Applying the GLID method

Inspired by the UX Laddering approach, Means-end Theory, and a social semiotic approach to multimodality, we developed the GLID method . The GLID method describes a data analysis approach to integrate textual, tangible and other co-design outcomes in a structured and coherent analysis. The method aims to arrive at a situated understanding of participants' values, and consists of four broad stages: (1) Grounding the analysis, (2) Listing design features, (3) Interpreting orientation and organization and (4) Distilling discourse and values. The development of the GLID method followed an iterative process in which we applied the insights from literature to the co-design outcomes of the second study as case material (for detailed descriptions of the results of case 2, see Derboven et al., 2015; Van Mechelen et al., 2016, 2015a, 2014c; Van Mechelen and Derboven, 2014). What we struggled most with was making the method into a practical tool that, at the same time, would not be perceived as a fixed cookbook recipe. Instead, the method would have to allow for an interpretative data analysis approach that could easily be adapted to different design contexts. Using the GLID method, we first engaged in the stage of grounding the analysis, and situated the final outcomes against the background of the initial ideas that came up during the sessions. By contextualizing the outcomes in this way, we wanted to clarify why certain design decisions were made.

We then listed all the design features of children's prototypes and their immediate functional consequences in detail (cf. Means-end Theory inspired data treatment). Relying on Multimodality, we then detailed how these design features were communicated in each mode (e.g. visual, textual). Whereas some features were communicated in both the artifact and in a verbal explanation, other functionalities were only expressed in one of these modes.

In the next stage, we interpreted these features on an orientational and organizational level. By analyzing the features' orientations, we determined which users were implicitly or explicitly involved in the interaction with the prototype and in what way. In turn, analyzing the features' organization helped us to determine how the various functionalities were brought together in a meaningful whole.

Finally, in the last stage, we analyzed children's discourse, which refers to how some aspect of reality is represented in a selective and socially constructed way (Van Leeuwen, 2005). This was essentially a coherent synthesis of the analysis from the previous stages. We thereby revealed which specific discourse children had used to envision future technologies and practices, and which value orientations could be deduced from this discourse.

6. 4. 5. 4 Preliminary findings

Reflecting on our newly developed approach, we learned that applying the different steps was not a linear deductive process. Instead, we had to do several iterations of going back and forth between the different stages. This was especially the case for the last two steps, which we considered as the most interpretative ones. To see if we (i.e., Van Mechelen, M. & Derboven, J.) would come to similar interpretations using GLID, we first analyzed the outcomes separately, and only afterwards compared our interpretations. Although the process of interpretation is not value free and thus could have resulted in different but equally valid readings, there were remarkable similarities. Minor differences were resolved by once more going through the data together.

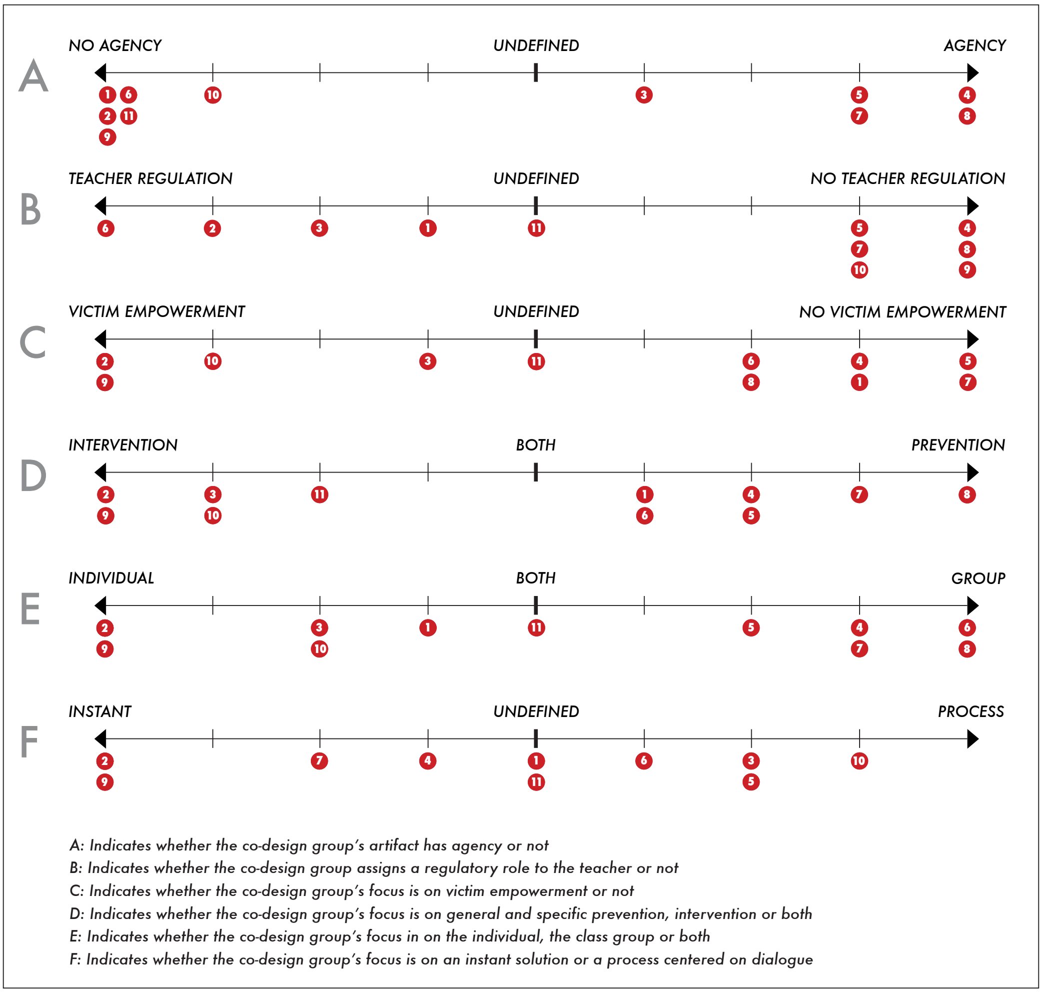

Figure 31: Visualization of orientations (A, B, E) and values (C, D, F) identified in case 2 relying on the GLID method; each number represents a co-design team

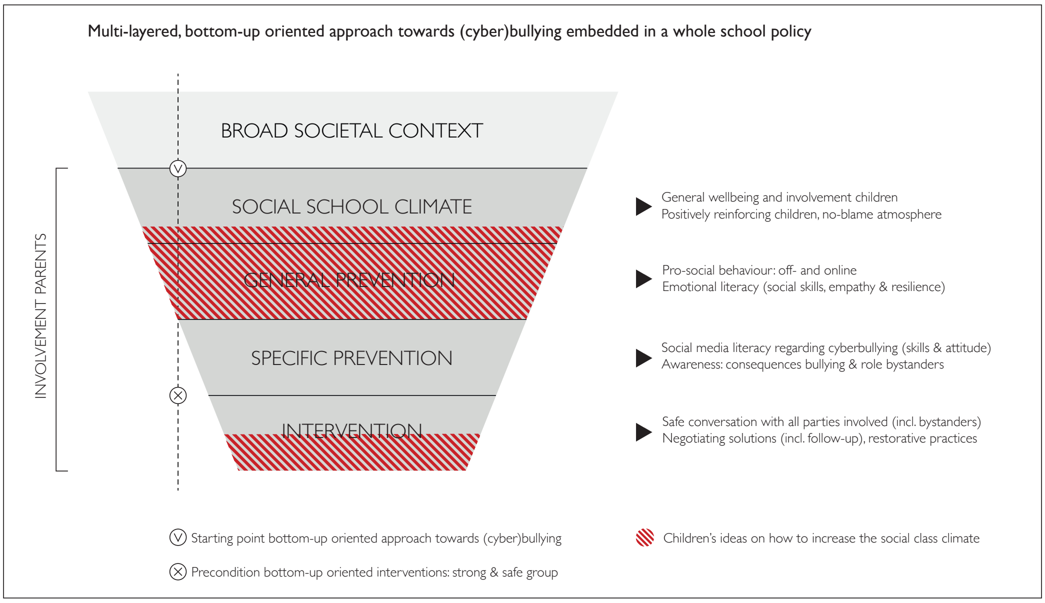

Figure 32: Children combined general prevention and intervention measures to combat (cyber-) bullying (red zones) whereas a team of experts proposed a multi-layered approach

In previous studies we struggled with combining children's ideas into a holistic design. We faced similar problems in this study that focused on the development of tools for children to safeguard a positive class atmosphere and prevent bullying. Many ideas and suggestions that children came up with were unrealistic (e.g. a hypnosis machine) or hard to reconcile with educational goals (e.g. a tool that helps to forget what happened as opposed to restorative practices). In addition, some co-design teams proposed designs that seemed contradictory (e.g. a tool for victims to turn their bullies into frogs vs. a robot that negotiates a solution between both parties). However, by changing our perspective according to the GLID approach, we were able to transcend these issues.

More particularly, identifying children's values embedded in the co-design outcomes enabled us to compare the ideas on a different, more abstracted level. Although the amount and diversity of ideas was still overwhelming, children's values seemed to be few and less volatile. With GLID, we could identify value conflicts between teams (see Figure 31), and between children and other stakeholders (e.g. educational experts). For instance, whereas we valued prevention and self-regulative behavior to create a safe class environment, most teams combined prevention and intervention measures in their designs (see Figure 32). Also, most teams hinted at a mix of top-down and bottom-up regulation to safeguard a positive atmosphere, yielding a different view on how to empower children than what we had in mind. As for the teams' emphasis on positive reconciliation in cases of bullying, this aligned well with our goal to create a safe and positive environment for children within a no-blame atmosphere.

In summary, by going beyond the surface level of children's ideas, we were able to reveal the underlying reasons and motives behind (opposing) ideas. Also, by explicating the link between the co-constructed artifact's attributes, its desired consequences and underlying values (cf. means-end ladder), we arrived at a better, more situated understanding of children's values. Through this linkage, the values were not detached from the problematic or puzzling situation they were intended to serve (i.e., the design challenge). We considered this vital, because when children are engaged in making activities, the values at stake and the solution being developed mutually influence each other. With GLID, we were able to identify children's discourse and value orientations resulting from this dialectic process and grounded in the artifact and its verbal explanation.
As a last step in the development of the method, we presented it in a 'what why how' structure in order for other design researchers to apply it to their own practice. The resulting stepwise procedure provides detailed guidelines to analyze co-design outcomes in a transparent and coherent way.

For more information about the GLID method, its theoretical foundations, and a practical example, we refer to Van Mechelen and colleagues (2016) and Derboven and colleagues (2015) in chapter *8. Publications research question RQ1b* (pp. 227), as well as section *9.3 The GLID analysis method* (pp. 286) in chapter *9. Co-design toolkit*. For a detailed description of all co-design outcomes that were used as case material to develop the GLID method, we furthermore refer to Van Mechelen and colleagues (Van Mechelen et al., 2014c).

6.5 Case 4: Developing children's singing talents

6.5.1 Rationale

The iMinds-MiX project MELoDia aimed at developing a mobile game-application for children aged 8 to 12, who have no or little experience with making music. The goal of the MELoDia application was to facilitate children to learn how to play music in a fun and engaging way, by providing immediate feedback on children's singing or music making activities. Although we were not directly involved in the project, two MELoDia researchers used a preliminary version of the SIT-inspired co-design procedure that we had developed in the first two cases. Based on our guidelines, they prepared and conducted a series of co-design activities with children. Their goal was to give children a say in the development of the application and to establish a process of mutual learning. After we had introduced the co-design procedure and had provided additional feedback on their application of the procedure, they conducted the co-design sessions without our help. This way, we wanted to evaluate whether the procedure was a useful tool for other researchers and in different design contexts. The goal of the fourth case study thus was to formatively evaluate the SIT-inspired co-design procedure.

6.5.2 Method

6.5.2.1. The co-design procedure

The MELoDia researchers developed a sensitizing package and conducted two co-design sessions with 17 children (10 girls and 7 boys) aged 8 to 10 in a primary school in Flanders, Belgium (see Table 4). The researchers met the children three times:

- Introduction of a sensitizing package with 3 individual assignments
- 1st co-design session focused on problem definition
- 2nd co-design session focused on prototyping a solution

When the researchers first met the children, they introduced themselves and the research project. To frame the co-design activities, they used a storytelling approach. The fictive story was about a 10-year-old boy who is learning how to play the guitar, but who experiences the music lessons as rather dull, compared to the digital games he frequently plays. For that reason, his father is looking for better ways to motivate and educate the boy so that he will continue practicing playing the guitar.

After one of the researchers told the story, a sensitizing package was introduced with three individual assignments. As in the other case studies, the goal of these assignments was to trigger children's reflection about the design theme. Some of the results were also used as input for the co-design activities. One such assignment was to make a self-portrait in which the participating children are engaged in music making in one way or another. Afterwards, the children had to write down what they like and do not like about playing music and why.

	School 1
Session 1	10 girls 7 boys
Session 2	10 girls 7 boys

Table 4: Total amount of participants in case 4: 17 children aged 8 to 10 in 1 school, divided in 4 teams of 4 to 5 boys and girls

The first co-design session that was scheduled two weeks after the introduction, focused on problem definition and relied on children's interpretation of the story. The teacher divided the children in four heterogeneous teams of four to five children, based on criteria such as personality (e.g., extravert vs. introvert) and skills. The researchers then briefly discussed the sensitizing assignments and some rules were agreed upon to streamline the collaboration process (e.g. work together and give everybody a chance to contribute). In addition, as suggested in our co-design procedure, each child was responsible for a certain practical aspect of the group process (e.g. timekeeper, material guard, presentation soldier, etc.). These roles were visualized on badges that children had to divide at the beginning of each session and wear during the co-design activities.

Next, the teams were asked to think of a group name and a slogan and to design a logo, and to present these group identity cues to the other teams. The main goal of this introductory design activity was to strengthen group cohesion and to get used to collaborating in a team. Afterwards, the researchers asked the teams to visualize (e.g. drawing, craftwork) the story in which a boy takes guitar lessons. In their visualization, the teams had to focus in particular on that what makes the lessons dull. They then had to select the most important reasons for which they would invent a solution in the next co-design session. These reasons were written down on text balloons and attached to the drawing or craftwork. At the end of the session, each team presented their co-created artifact to the other teams who could ask questions and voice their opinion.

The second co-design session was scheduled one week later and focused on problem solving by means of low-tech prototyping. After introducing the overall goal of the session, the teams were asked to reallocate the roles and they received a bag with low-tech prototyping materials (e.g. markers, crayons, paper, scissors). After a short warm-up exercise (classical brainstorming), each team started brainstorming solutions for the design problems they had defined during the previous session based on their interpretation of the story. Although children worked in teams, they brainstormed ideas individually. The assignment was to think of game-like solutions that would make the boy's music lessons less dull. After brainstorming, the individual ideas were pooled together per team, and each team selected the best idea through sticky dot voting. Each team member had two votes (i.e., two little stickers to put on the most favorite ideas), but could not vote for his or her own ideas.
Based on the selected ideas, the teams started prototyping an educational music game with the low-tech prototyping materials handed out at the beginning of the session, resulting in one paper prototype per team. When finished, the presentation soldier of each team presented their prototype, and the other teams could ask questions and give constructive feedback. The session ended with a short wrap-up in which the researchers explained the next steps of the project.

As for the analysis, we did not provide any guidance because we were still developing our GLID method at that point. In the official research report that was written at the end of the MELoDia project, we read that the involved researchers used some kind of grounded theory based approach to thematically cluster the data, which they then translated into a list of functional requirements for a gamified educational music application.

6. 5. 2. 1 Evaluation set-up

We met the researchers involved in the MELoDia project two times. During the first meeting some weeks before the co-design activities, we explained the SIT-inspired co-design procedure. During the second meeting right after the activities, we interviewed the researchers about how they experienced the use of the procedure. Based on our guidelines, the MELoDia researchers prepared the co-design activities. Via e-mail, we evaluated how they applied our guidelines and, when necessary, provided additional instructions.

We asked the researchers to write a short report immediately after each co-design activity to document their experiences with the co-design procedure. We asked them to focus on the collaboration between children (how the interacted, made decisions together, dealt with differing voices, etc.), how they approached the different tasks, and the amount of adult facilitation that was needed (e.g. for class management purposes). Based on these reports, we prepared a semi-structured interview. The questions were clustered thematically based on the predominant themes in the reports (e.g. sensitizing, storytelling, group processing, peer jury, boundaries vs. freedom). The interview took about two hours, was audio recorded, and transcribed for analysis afterwards. The results of this formative evaluation were used to further develop the SIT-inspired co-design procedure and to develop a co-design toolkit.

6.5.3 Expectations and findings

In general, the formative evaluation resulted in useful recommendations to refine the SIT-inspired co-design procedure. However, reflecting on how we arranged the initial meeting and provided additional instructions, not everything went according to plan. For instance, one researcher did not attend the initial meeting and was not actively involved in the communication via e-mail afterwards. This made it very difficult to accurately communicate the different steps and underlying rationale, especially because we had not yet fully documented our co-design procedure at that point. Nevertheless, we hoped that the MELoDia researchers would provide us with constructive feedback on how to improve the procedure in the concluding interview, which they both attended.

When analyzing the reports written by one of the researchers to prepare the interview, we soon noticed that not all steps were implemented as described. Apparently, it was not clear how certain steps could improve children's collaborative and creative efforts in co-design activities. For instance, one step that we found vital, group processing, was not implemented at all. The researchers also gave a much more prominent role to the teacher than we had envisioned, making it hard to compare our experiences with theirs. Better insights in the procedure's theoretical foundations might have prevented these issues. Despite these drawbacks, which were mainly caused by insufficient communication, we learned some important lessons.

When the MELoDia researchers met the children for the first time, they explained the design theme and what their role was as researchers. Children reacted enthusiastically, thus the right atmosphere was set from the start. However, introducing the fictitious story after this introduction felt as a forced fit, because they had to differentiate between the goal of the project, developing a gamified educational music application, and the fictitious story. In their opinion, the use of storytelling could be a worthy approach in sensitive design contexts or when working with younger children, but was experienced as redundant in this project focusing on children aged 8 to 10.
Apparently, the researchers had interpreted the function of storytelling differently. In the SIT-inspired co-design procedure, storytelling is used to frame the co-design activities and strengthen outcome interdependence. In order to do so, the story should provide focus, but at the same time leave room for problem finding to occur. It seemed that we had insufficiently communicated this underlying rationale. During the interview, the researchers acknowledged that they noticed an increase in problem ownership after teams had defined a problem based on their interpretation of the story (1st co-design session). They considered this to be essential in PD practices.
During the introductory meeting, the researchers furthermore introduced the sensitizing assignments. Each assignment was put in a sealed envelope and the results had to be dropped in a mysterious box in front of the classroom. According to the researchers, this approach fostered children's curiosity and willingness to participate in the co-design activities. Moreover, the researchers stated that the data that resulted from the sensitizing assignments were a great source of inspiration for the further design process.

During the first co-design session approximately two weeks after the introduction, the researchers reiterated the story and design challenge, and introduced a set of boundaries or rules. For instance, children were asked to stick with their team, listen to each other and give every team member an equal chance to contribute, pay attention when instructions were given, and take good care of the prototyping materials. The researchers admitted that, from the very start, they were not convinced about the usefulness of these rules in co-design activities with children. They found that they were not in a position to say what children could or could not do, because they were the ones asking for help.
Moreover, they argued that the use of rules felt against the very nature of co-design activities that should be centered on fun and creativity. Thus, instead of encouraging children to make their own choices within a set of boundaries in analogy with a positive or authoritative parenting style, the researchers seemed to prefer a permissive or indulgent style which

is characterized by placing no or few demands and rules on children (Baumrind, 1967; Santrock, 2007). Somewhat contradictory, however, the researchers relied on the teacher to “resolve disputes” or “call children to order” when they did not do what was expected. Apparently, they felt not qualified to intervene when something went wrong.

After introducing the rules, children had to divide the different roles and responsibilities, which was not without difficulties either. The researchers explained to us that role division took a lot of time and resulted in conflicts about who was responsible for a certain aspect of the teamwork. It turned out that some children showed inflexible behavior and held on to their first choice. It was the teacher who had to solve these conflicts, either by enforcing or negotiating a solution (e.g., by allocating a single role to multiple children). Despite these interventions, the researchers felt that children did not do much with their roles in the subsequent design activities, which made them question the purpose of the technique.
Probably we should have better communicated that, in SIT-inspired co-design, the roles are used to increase task cohesion and increase feelings of responsibility. Children should not cherry pick roles, but negotiate which role is best suited for whom and why. Although this may be a difficult task, children need these negotiation skills to collaborate successfully. Role division should therefore not be regarded as a waste of time. Another lesson learned is that we should have explained that children need time to practice these roles before moving on to more complex design tasks such as low-tech prototyping. Providing specific tasks for each of these roles can help to remind children of their responsibility within the team (e.g., time keeper receives a clock, the material guard the bag with prototyping materials).
When the teams eventually succeeded in dividing the roles with the help of the teacher, the researchers facilitated teambuilding activities to strengthen social cohesion. Children were asked to come up with a group name and a slogan, and to design a logo. The researchers confirmed that this was a valuable intermediate step that prepared the teams for the more complex design tasks.

Reflecting on the jury approach, the researchers found that it did not result in lively debates, especially not in the first session. We believe the researchers could have taken a more active role in facilitating the discussion, because the only questions they asked were “How did you like it?” and “Questions anyone?”. To some extent, the researchers also hinted upon this during the interview, as they suggested that a topic guide or a list of questions would have been useful, both for the facilitators and the children.

Group processing, the next step in the SIT-inspired co-design procedure, was only applied at the end of the first session. The researchers did not see how group processing could improve children's collaboration over time, and only found it useful to quickly evaluate the co-design activities. Instead of facilitating group processing as a team activity, the researchers just asked whether or not children liked working together, and then wrapped up the session because children looked tired. This felt as a missed opportunity to us, because we do not think that children will learn as much from their collaborative experiences if they do not take time to reflect on these experiences. In SIT-inspired co-design, we foresaw time for teams to consider three actions that were helpful to accomplish the team's goals, and one action that could be added or changed in the next session, which we found as a useful approach to strengthen the team's cohesion and improve collaboration.

In the second co-design session, similar problems were faced regarding role division, the use of rules and peer jurying, and group processing was no longer implemented. The researchers did not observe any noteworthy evolution in children's collaborative efforts from the first to the second session.

As for the occurrence of challenging intragroup or co-design dynamics, the researchers implicitly referred to three dynamics during the interview: the Unequal Power dynamic, Dysfunctional Conflict and Free Riding. According to the researchers, some children used their higher status to force their ideas upon the team, for instance during the selection phase. This often resulted in heated debates, and although conflict sometimes helped children to get rid of frustrations and generate novel ideas, in most cases conflict had a detrimental effect on the group process. Moreover, in cases of Dysfunctional Conflict, it took a lot of time for the teacher and the researchers to reestablish a good team atmosphere. The researchers observed that most conflicts occurred when children were dividing the roles and when they were selecting ideas for further elaboration. Additionally, during the making activities there were regular disputes about how to approach the task. Contrarily, during the presentation at the end of the session, most teams seemed proud of their accomplishments and stood up for one another. This confirms a previous finding (2nd case) that children usually want to make a good impression in front of their peers, and that peer jury can increase group accountability.

The researchers also observed cases of Free Riding but these were mostly due to language barriers. Apparently some children did not speak Dutch very well, something the researchers had not anticipated on.

An overall concern about the SIT-inspired co-design procedure expressed by the involved researchers was the amount of time needed to prepare and conduct the activities. The researchers wondered whether two co-design sessions were really needed, and whether the same results could be attained in only one session of approximately two hours. Because the researchers met the children three times, they did confess, however, that it became gradually easier to fulfill their role as facilitator because they got to know the children.

Another stumble block was the inflexibility of the procedure, which the researchers perceived as overly structured. A lot of on-the-spot adaptations were needed, especially with regard to the timing of the different steps. The amount of structure provided by the SIT-inspired co-design procedure seemed to contradict with the class and school culture (i.e., a Freinet-based school), in which children were granted more autonomy than regular state schools. An important lesson learned here is that the procedure should not be presented as a single-method formula, and should be carefully adjusted to the context in which it is applied. Moreover, we acknowledge that co-designing technology with children asks for a flexible attitude from researchers, because not everything may go as planned.

At the same time, the researchers recognized that the way in which the procedure guided children through the creative mechanisms of Design Thinking in consecutive steps of divergence (e.g., sensitizing, ideation, elaboration through making) and convergence (e.g., problem definition, grouping and selection, presentation) was very helpful. Apparently, it was not so much the implementation of Thöring and Muller's (2011) Design Thinking model that the researchers experienced as problematic, but rather the application of SIT's mediating principles (Johnson and Johnson, 2009, 2005).

6.5.4 Developing the CoDeT co-design procedure

Although the MELoDia researchers did not follow all our guidelines on how to implement the SIT-inspired co-design procedure, we could nevertheless draw some lessons. The most important ones are that we should frame the procedure as a reflective tool, and that we should clearly explain the underlying rationale of the suggested steps. Another lesson learned, is that we should provide better guidelines on how design researchers can address challenging intragroup or co-design dynamics, instead of relying solely on children's teachers who may not always be present and are not trained as designers.

Based on previous experiences, we learned that children are not always capable of managing differing voices productively. When intervention is needed, a no-blame approach is recommended rather than an authoritarian or restrictive one. Finally, with regard to setting boundaries, we learned that we should not be too rigid or school-like, because that may conflict with the creative nature of co-design activities. The goal of setting boundaries (e.g., through rules of the game) is to create a framework within which children can collaborate freely and in mutual respect for one another. This corresponds with a positive or authoritative parenting style in which children are encouraged to make their own choices but, simultaneously, limits are placed on some of their actions and a certain degree of maturity is asked for (Baumrind, 1967; Santrock, 2007).

We incorporated these and other lessons in the CoDeT co-design procedure. CoDeT stands for Collaborative Design Thinking and relies on both SIT's mediating principles for effective collaboration (Johnson and Johnson, 2005; 2009) and Thoring and Müller's divergent-convergent Design Thinking model (2011). In the description of the procedure (see section *9.2 The CoDeT co-design procedure* on pp. 270 in chapter *9. Co-design toolkit*) we provide clear arguments for each of the suggested steps, and we give numerous examples on how these steps can be implemented in co-design activities. Similarly to the previously described cases, we believe that CoDeT is especially useful for co-designing technology with children in a school environment at a rather high child-to-adult ratio (i.e., 1 adult for ca. 15 to 20 children). We call upon future researchers in the CCI community to apply and modify the CoDeT co-design procedure in a wide variety of design contexts.

A preliminary version of the co-design procedure is presented in Derboven and Van Mechelen (2015) in chapter *8. Publications research question RQ1b* (pp. 227). For the final version of the CoDeT procedure, we refer to section *9.2 The CoDeT co-design procedure* (pp. 270) in chapter *9. Co-design toolkit.*

6.6 Conclusion

In this chapter we discussed four cases that form the main thread of this PhD research. The overarching research question that links these different cases into a multiple-case embedded design is how to design technology for children with children. Throughout this chapter, we reflected on the different steps taken, our underlying motives, expectations and findings, and we explained how we took our newly gained knowledge from one case study to the next. In doing so, this chapter brought together insights from literature discussed in previous chapters and used as a theoretical foundation to develop a co-design toolkit (see chapter *9. Co-design toolkit* on pp. 269 for a detailed description of the toolkit). To capture the interaction between theory and practice in our PhD research, this chapter was written in a narrative and linear fashion. In a more formal writing style, it would have been difficult to capture this dialectic process between theory and practice, and the insights it revealed.

As for the co-design toolkit resulting from this research, the first part focuses on how to efficiently structure cooperation between children in co-design activities (the CoDeT co-design procedure). This research question emerged in the first case in which we were confronted with challenges in facilitating different teams of children at a rather high child-to-adult ratio (i.e., one adult for 15 to 20 children). These challenges were addressed in the second and fourth case and ultimately resulted in the CoDeT procedure. The main goal of the procedure is to mitigate challenging intragroup or co-design dynamics that may occur between children and hamper their creative abilities. The procedure integrates a design-thinking model proposed by Thoring and Müller (2011) and insights from Social Interdependence Theory (Johnson and Johnson, 2005; 2009).

The second part of the toolkit focuses on how to analyze co-design outcomes in a coherent and transparent way in order to arrive at children's negotiated values (the GLID method). This question also emerged in the first case, but was not addressed until the third case. The outcomes of the second study were retrospectively used as additional case material. For GLID, we relied on Means-end Theory and a social semiotic approach to Multimodality. We were furthermore inspired by a values-led approach to Participatory Design and the discourse surrounding Value Sensitive Design. The goal of the method is to arrive at children's negotiated values embedded in co-design outcomes by integrating textual, tangible and other modes into a coherent and transparent analysis.

PART 2: RESEARCH OUTPUT

7. Publications research question RQ1a

Chapter 7 presents three published papers dealing with the first research question on scaffolding collaboration and mitigating challenging group dynamics between children in co-design activities (cf. RQ1a). The author of this PhD thesis presented all three publications at the ACM Interaction Design and Children (IDC) conference. The first two (see sections 7.1 and 7.2) as short papers at IDC 2014 in Aarhus (Denmark), and the third one (see section 7.3) as a full paper at IDC 2015 in Boston (US). The first author came up with the concept and the structure and did the main part of the writing for all three papers. The co-authors had an advisory role and proofread the manuscripts.

7.1 Exploring challenging group dynamics in Participatory Design with children

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7.1.1 Abstract

This paper presents a structured way to evaluate challenging group or co-design dynamics in Participatory Design processes with children. In the form of a critical reflection on a project in which 103 children were involved as design partners, we describe the most prevalent co-design dynamics. For example, some groups rush too quickly towards

consensus to safeguard group cohesiveness instead of examining other choice alternatives (i.e., Groupthink). Besides Groupthink we describe five more challenging co-design dynamics: Laughing Out Loud, Free Riding, Unequal Power, Apart Together and Destructive Conflict. We argue that balancing these dynamics has a positive impact on the dialectic process of developing values and ideas in Participatory Design, as well as on children's motivation. Therefore, the CCI community could benefit from our in-depth exploration and categorization of challenging group dynamics when co-designing technology with children.

Categories and Subject Descriptors
H.5.2 User Interfaces, Theory and methods, User-centered design

General Terms
Design; Performance

Keywords
CCI; co-design; group dynamics; values; Participatory Design

7.1.2 Introduction

Participatory Design has urged us to consider users as co-designers of their technology and of the practices that may be reified in that technology. Within the area of Child Computer Interaction (CCI) children have participated in the design of technology for over two decades using a variety of established methods (Dindler et al, 2005; Mazzone et al, 2010). These methods typically involve children in dyads or groups, rather than individually. The use of groups in Participatory Design reflects a theoretical commitment to the notion that meanings are socially and collectively produced (Buckingham, 2009).

7.1.2.1 Negotiating values

Recently, attempts have been made to rekindle values in what is called a more authentic approach towards Participatory Design (Iversen et al, 2010). During design activities, children's values may be implicitly expressed as something they care about and find important. Values do not progress stepwise in one direction. Rather they emerge, develop and ground recursively and dialogically over the course of the design process (Iversen et al, 2010). The way we work with values in Participatory Design with children is centered on dialogue.

Therefore, one of our core tasks as researchers is to orchestrate this dialogue with and among children and to make sure value conflicts are transcended and translated into meaningful design concepts. Special attention should thereby be given to group dynamics that may impact this dialogical process.

7.1.2.2 Group dynamics

Within the area of CCI, authors have only recently started to acknowledge the importance of facilitating group dynamics in co-design with children, e.g. (Vaajakallio et al, 2010). Focusing on group dynamics is believed to have a positive impact on children's motivation as well as on the development of creative solutions (Cross & Cross, 1995). Nevertheless, the concept group dynamics remains generally poorly defined within the field, and little solutions to overcome challenging group dynamics have been suggested. Also, the majority of CCI authors tends to focus primarily on remediating asymmetrical power relationships between adults and children, e.g. (Druin, 2002; Guha et al, 2013; Mazzone et al, 2010). Therefore, the CCI community would benefit from an in-depth exploration and categorization of challenging group dynamics when co-designing technology with children.

The term group dynamics was first coined by social psychologist Kurt Lewin (1945) and refers to a system of behaviors and psychological processes occurring within a social group (i.e. intragroup dynamics), or between social groups (i.e. intergroup dynamics) (Franz, 2012). In this paper, we refer to co-design dynamics as a system of intragroup dynamics occurring within a group of children sharing a common design goal.

In the form of a critical reflection, this paper presents a structured way to account for challenging co-design dynamics within groups of children. In section 2 we describe a project in which children were involved as design partners. In section 3 we reflect upon these co-design activities, presenting the most prevalent dynamics we encountered during the project, and in section 4 we discuss our categorization of challenging co-design dynamics and touch upon topics for further research.

7.1.3 Case study

The study took place in three schools in Flanders, Belgium. All children were in the fourth grade of elementary school, aged 9 to 10. Each class, ranging from 19 to 30 children, was divided in a morning- and afternoon group. In sum, 103 children were involved. At the beginning of each co-design session, these morning- and afternoon groups were split up in two to three gender-mixed subgroups of four to six boys and girls. Literature has shown this to be the most optimal group size (Heary and Hennessy, 2002). Also, many authors suggest that heterogeneous groups are more capable of coming up with diverse ideas (Druin, 2002; Sawyer, 2008). Therefore, with the help of the children's teachers, these subgroups were formed heterogeneously, based on criteria such as intelligence, communication skills, gender and creative abilities.

Over a period of two months, four co-design sessions were organized in each school on the theme of arts and culture education. We thereby divided our general design theme into subtopics, one for each co-design session:

- Session 1: organizing a fun and engaging class excursion.
- Session 2: making schoolwork both fun and engaging.
- Session 3: designing a fun and engaging website for learning.
- Session 4: inventing technology to assist schoolchildren on a museum visit.

7. 1. 3. 1 General procedure

We used a blend of two different approaches to co-design: Cooperative Inquiry (Druin, 2002) and the Contextmapping procedure as described by (Sleeswijk Visser et al, 2005). The goal of Cooperative Inquiry is to support intergenerational design teams in understanding what children as technology users do now, what they might do tomorrow and what they envision for the future (Druin, 2002). Contextmapping on the other hand is a systematic approach to elicit contextual information of product use. Generative techniques are often used in Contextmapping. The basic principle thereby is to let people make designerly artifacts and tell a story about what they have made (Sanders, 2000; Sawyer, 2008).

Two researchers were involved in each co-design session: one facilitator who interacted with the children and one fly-on-the-wall observer making notes. In addition, the whole session was recorded on video and a report was written immediately afterwards. Each session lasted for about 150 minutes and typically consisted of the following stages:

Sensitizing

By means of an individual assignment we triggered children's reflection in a playful and creative way before the actual co-design session. Approximately one week ahead of each session, we introduced an assignment in the children's classrooms. They then continued working on it at home. In one such assignment, future classroom, we asked the children to draw or prototype their ideal classroom of the future. In the co-design session that followed (i.e. session 2: making schoolwork both fun and engaging), the children discussed their drawings or paper prototypes for the first 10 to 15 minutes. Through this warm-up, children were better able to access their experiences and values and to express their ideas regarding the co-design session's topics. This is in line with (Sleeswijk Visser et al, 2005) to whom we refer for more detailed information on sensitizing.

Introduction and warm up

The session took place in an available room in the school. First, the children were divided into two to three teams of four to six boys and girls depending on the class size. Then, the adult facilitator explained the co-design session's topic as well as the rules such as "listen to each other", "there are no bad ideas", and "you may walk around but stick to your team". The latter activities took about 10 to 15 minutes. Next, the facilitator warmed up the children for another 10 to 15 minutes by discussing the results of the preceding sensitizing assignment. During these discussions, children's values were implicitly expressed as something they care about and find important. This way, a problem space was identified that children felt is worth tackling.

Ideation and selection

The facilitator handed out post-its and markers and explained the rules for ideation (i.e. defer judgment, encourage wild ideas, build on the ideas of others and go for quantity) (Sutton and Hargadon, 1996). The children were then encouraged to brainstorm, writing down as many ideas as possible on post-its. Although brainstorming's effectiveness has been questioned, the technique should not be evaluated in isolation here, since we combined it with individual reflection (cf. sensitizing) and low-tech prototyping (cf. elaboration) (Sutton and Hargadon, 1996). Each design team had five minutes to brainstorm ideas. Then they were asked to group similar ideas together. Finally, each team member could vote for his or her favorite ideas by means of three little stickers (i.e., sticky dot voting) (Gray, 2010). Only one vote could be given to one of their own ideas. The most popular ideas were taken to the next stage for further development.

Elaboration through making

In this phase, children elaborated hands-on on the selected ideas. The facilitator explicitly asked the teams to mix the three previously selected ideas into one big idea (Guha et al, 2013). They could either visualize their big idea through a collage or make a paper prototype out of it. For this purpose, each team had a generative toolkit (Sanders, 2000) at their disposal made up of two-dimensional components ranging from figurative to abstract (e.g. paper shapes, stickers and color photographs). The teams had about 45 to 55 minutes to visualize or prototype their big idea. Again, since space is limited, we refer to (Sleeswijk Visser et al, 2005) for a more detailed description on the use of generative toolkits.

Presentation and discussion

In approximately five minutes, the teams prepared a presentation about their design. When one team was presenting their collage or prototype and the ideas and values embedded in it, the other teams functioned as a jury. After the presentation, the jury could ask critical questions about the design. We stressed that the jury should focus on the design's quality rather than on the form of the presentation. The facilitator moderated this dialogue between jury and design teams and asked some additional open-ended why questions inspired by UX laddering as described by (Zaman & Van den Abeele, 2010). Thereby, the deep reasons and values behind certain design decisions were revealed. After each team had presented and discussed their collage or prototype, a short wrap-up followed and the session ended. Presentation and discussion took about 15 minutes per team.

7.1.3.2 Analysis

We qualitatively analyzed the data by means of open and axial coding. The raw data consisted of observation notes, reports written after the sessions, co-design artifacts, video footage and transcripts from the presentations and discussions.

7.1.4 Co-design dynamics

The framework presented below is not exhaustive and although some of these challenging dynamics may not seem novel at first sight, they have rarely been addressed explicitly in CCI and in literature on co-design methods.

7.1.4.1 Unequal Power

Some co-design groups quite openly followed the opinions and ideas of the most dominant or charismatic team member. These children were enjoying a higher status and had a tremendous impact on the group process, either positively or negatively. They might for example capitalize on the situation to force their ideas and values on the group and undermine team effectiveness. A co-design dynamic that we label as Unequal Power in analogy with social psychologist (Franz, 2012). This makes it difficult for children with a lower status to voice their opinions, limiting their influence in the group. Many times, these children appeared to be rather shy in contrast to the more dominant, high-power children. Thus, group members with more power than others have a higher likelihood of swaying any final decision by direct or indirect pressure as well as through the time they are allotted for discussion.

7.1.4.2 Free Riding

The results showed that some children took advantage of the work of others in the team. These children may have felt less accountable to contribute, so they devoted less effort. A dynamic that we label as Free Riding in analogy with a particular kind of Social Loafing described by social psychologists (Sutton & Hargadon, 1996) as "the reduced social motivation that occurs when certain members decide to let the others contribute and choose not to fully participate". Free Riding may easily manifest itself during co-design activities. For example, one particular child took a free ride almost every co-design session, no matter what group he was in. He hardly did anything and sometimes he was even counterproductive by making jokes about the others who became visibly agitated. Surprisingly, he tried to take credit for the ideas during presentation by intervening repeatedly when someone else was talking. Although this was a rather extreme and rare case of Free Riding, milder forms were very common.

7.1.4.3 Laughing Out Loud

In some cases we noticed co-design groups ganging up on the task. They were having a good time, but there was an unwillingness to take the task at hand serious. In such groups, the atmosphere was rather disruptive instead of constructive. This may be due to a lack of intrinsic motivation and problem ownership. When team members do not gradually uncover and identify their values, it may become problematic to identify a problem space they feel is worth tackling as a group.

Sometimes, this tendency towards an unserious atmosphere was a gradually evolving process. At the start of one particular co-design session, only two out of five group members were giggling while coming up with rather silly and irrelevant ideas. After a while, this behavior affected the other children in the group and once the session was half way, their priorities as a group had shifted from finding a design solution to having a good time.

7.1.4.4 Apart Together

Some of the group's designs were a disconnected mix of rather individual designs lacking an overall design vision. Instead of mixing ideas and working toward one integrated design, the children followed their idiosyncratic interests and only in the end they combined the individual designs quite literally. In one such example, each of the group's members invented a piece of magical technology to guide schoolchildren during a museum visit. By drawing ropes between them, they combined these individual designs afterwards. Among the individual designs were a minimize device to make souvenirs from artworks and historical buildings, holographic video glasses that could project a virtual guide in front of you and an electronic notebook with an integrated ask a question dice game. When presenting, it became clear they had not negotiated their personal values and ideas profoundly. As a consequence their final design lacked an overall design vision.
Children from other teams confirmed this after the presentation. They literally questioned the feasibility of the idea, already anticipating that all these components together would weight a lot so that it would be impossible to carry it while walking in the museum. Different and contradictory answers followed. It was obvious the team members had not thought profoundly about this matter. This may be due to a lack of communication within the team, but it may also depend largely on the developmental characteristics of children this age.

7.1.4.5 Deconstructive conflict

We noticed that some children had a difficult time letting go of their initially chosen ideas. This complicated negotiating ideas with other team members during the selection phase. Children were not always capable of managing such conflict or differing voices productively, leading to a polarization within the team. Such negative or competitive behaviors between team members may reduce trust and it is being known in other fields such as social psychology and cooperative learning that the lack of trust reduces group cooperation (Franz, 2012; Johnson & Johnson, 2005). Based on our observations, this also holds true for co-design activities with children. Although conflict may be an essential process to move teams towards necessary change and creative breakthroughs, it must be managed. If not, conflict easily becomes destructive, causing defensive behavior, inflexibility, contempt and an unwillingness to work together.

7.1.4.6 Groupthink

The dynamic of Groupthink occurred in some teams with high group cohesiveness. Psychologist Irving Janis coined the term Groupthink to describe a phenomenon in which "the group ends up being dumber than its individual members" (Sawyer, 2008). In our study, Groupthink happened when children were reluctant to criticize each other's ideas. They then kept on adding functionalities to please everyone and eventually ended up with a design featuring too much functionality. Although a strong, overall design vision was lacking, this was not the result of any problems in the collaboration process as for instance was the case in the Apart Together dynamic.

A technology-enriched fur coat, designed by one of the teams is a striking example. At first sight, the children collaborated successfully and no tensions were observed. However, during prototyping they kept on adding overlapping functionalities to their technology-enriched fur coat. It seems like they wanted to please every team member to safeguard the positive atmosphere in the group. In doing so, they got more and more off track and they gradually lost sight of the design goal, ending up with a design doing too many things at once. This was made explicit by the opening sentence of their presentation, in which they announced their design as the everything fur coat. This emphasis on concurrence seeking instead of fully surveying choice alternatives subsequently increases the possibility of poor decision-making, as confirmed by social psychologists (Franz, 2012). Value conflicts in such groups are often neglected rather then negotiated and transcended, which makes it less likely for creative breakthroughs to emerge.

7.1.5 Discussion and future work

The goal of this paper was to present a structured way to evaluate six challenging co-design dynamics that may occur in Participatory Design practices with children. The categorization is not exhaustive and only includes the most prevalent challenging dynamics encountered so far. We believe that balancing these dynamics has a positive impact on the dialectic process of developing values and ideas in Participatory Design, as well as on children's motivation. The CCI community could thus benefit from our in-depth exploration and categorization of challenging group dynamics when co-designing technology with children.

These dynamics may be closely linked. For example, a group may fall into the Groupthink trap because the viewpoints of a dominant and charismatic child (cf. Unequal Power) are agreed upon too soon without critical examination of other alternatives. Groups rushing too quickly towards consensus and agreement could actually benefit from a mild form of conflict. Although conflict is often perceived as a negative force while cooperation is at the other end of the continuum, their impact on group performance is more nuanced than that. In fact, conflict can be a positive force because it can create energy around sharing diverse information and viewpoints. The challenge is to avoid groups moving from constructive to dysfunctional and Destructive Conflicts (Franz, 2012). In future work, we will further investigate these complex interrelationships.

Currently, we are looking more deeply into other fields such as educational pedagogy and in particular conceptual approaches to Cooperative Learning have gained our interest, e.g. (Johnson and Johnson, 2005). We have been translating solutions from an educational into a co-design context. For instance, by having children take on different roles as timekeeper, inspiration general, material guard, and so on, positive interdependence will be enhanced. The idea is that if children value their group members as a result of cohesiveness-building activities and are dependent on one another, they are likely to encourage and help one another to succeed, because they perceive that their effort is important for the entire group (Johnson and Johnson, 2005). In future work, we will further translate solutions from an educational into a co-design context and validate promising solutions rigorously.

7.1.6 Conclusions

In this paper, we have defined co-design dynamics as a system of intragroup dynamics occurring within groups of children sharing a common design goal. These dynamics clearly impact the dialectic process of developing values and ideas in Participatory Design. These challenges, however, have rarely been addressed in the field of CCI and in the literature on co-design methods.

The dynamics encountered in our study are the Apart Together phenomenon (i.e., working individually and only combining results quite literally in the end), Free Riding (i.e., reduced effort by some individuals when working in a co-design team and taking advantage of the others), Unequal Power (i.e., some children come to the co-design tasks with higher status than others and vice versa), the Laughing Out Loud phenomenon (i.e., an unwillingness to take the task at hand serious as a group), Destructive Conflict (i.e., escalating disagreements about which ideas too work on further) and Groupthink (i.e., rushing too quickly towards consensus neglecting choice alternatives). We strongly believe that focusing on these dynamics is essential to better engage with values in

Participatory Design (Iversen et al, 2010). Therefore, the CCI community could benefit from our in-depth exploration and categorization when co-designing technology with children. In future work, we will further investigate how these challenging co-design dynamics are interrelated and how they can be balanced and remediated into positive forces.

7.2 Applying the CHECk tool to Participatory Design sessions with children

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7.2.1 Abstract

To encourage ethical practices in Participatory Design with children the CHECk tool was created. This paper reports on an expert review of the CHECk tool and a validating case study. Four main challenges to the CHECk tool are identified: (1) how to inform children on the research and their role herein, (2) distinguishing between project values and designer or researcher's personal values, (3) accounting for the dynamic nature and social constructedness of values in design, and (4) the emergence of values in all stakeholders including child design partners. We advocate complementing CHECk with interactive storytelling and show how this narrative can be used to not only inform participation and achieve ethical symmetry, but also to negotiate values with child design partners.

Categories and Subject Descriptors

K 4.1 [Public Policy Issues] ethics

General Terms

Human Factors

Keywords
CCI; Participatory Design; Value Sensitive Design; ethics

7.2.2 Introduction

Within the area of Child Computer Interaction (CCI) children have participated in the design of technology for over two decades using a variety of established methods (e.g. (Bekker et al., 2003; Dindler et al., 2005).

Technology has moral impacts on users and their environment, it shapes their lives and practices in important ways. Technology is therefore not merely enabling but constitutive. On the other hand, users may appropriate technology for purposes other than those intended in design and, by doing so, technology's functionality is adjusted and changed. Such an interactional position holds that values are not solely designed into technology, nor are they solely conveyed by social drivers and forces, it works both ways (Manders-Huits, 2011).

Since technology should no longer be considered value-neutral, an increasing body of HCI (and CCI) research has concerned itself with understanding how to explore values more explicitly during design and evaluation. At the same time, a number of approaches for systematically considering human values in information technology have emerged, in particular value sensitive design (Friedman, 2006; Borning & Muller, 2012). Furthermore, in related fields such as Participatory Design attempts have been made to rekindle values in what is called a more authentic approach towards Participatory Design (Iversen et al, 2010). In this paper we rely on Rokeach's (1973) notion of values as something that a person or a group of persons consider(s) important in life, as have many others, e.g. (Friedman et al, 2006; Iversen et al, 2010).

To encourage ethical practice in Participatory Design with children a value checklist referred to as CHECk was created for use prior to and at the start of design activities (Read et al, 2013). CHECk, consists of two checklists, CHECk 1 and 2, designed to help CCI researchers to critically consider their values when involving children in design projects, and to examine how best to explain Participatory Design activities to children to aid informed consent (Read et al, 2013).

In this paper, we advocate complementing CHECk with interactive storytelling and using this narrative to not only better inform participation and achieve ethical symmetry, but also to negotiate values concerning the project and its outcomes with our child design partners. This way, CHECk becomes a vehicle to open up dialogue and to establish a shared narrative space, that is, a common ground where adults and children can meet.

7. 2. 3 Examining values and participation

Examining your own values as a researcher or designer prior to any design activity is a condition sine qua non to better inform child design partners. Using tools like CHECk fits in a broader general trend in the HCI and CCI community that has often been referred to as the third wave of HCI research (Bødker, 2006). This transition came with a turn to design and culture as new theoretical concerns, indicating a trend towards more critical reflection (Löwgren and Stolterman, 2004). It has called for accountability in the ethnomethodological sense in that researchers and designers are increasingly expected to explicitly account for what they are examining, designing and the procedures followed to perform these practices (Hallnäs and Redström, 2002). It does not only call for a responsibility to account for the values that are being designed for, but also for a reflexivity regarding the fact that interaction designers and researchers themselves bring values to the design process (Sengers et al, 2005). Design and research teams therefore need adequate codes or tools.

However, ethical questions that arise when involving children as design partners are not always considered in a standard ethics review (e.g. ownership of ideas). In addition, informed consent documents usually target parents rather than informing both adults and children. Finally, there is an urge for an added layer of ethical discussion, indicating personal responsibility to do more than just the minimum.

In order to support CCI researchers and designers to become accountable for the values that they design for, Read et al. have developed CHECk, a tool to encourage reflexivity, consisting of two checklists (Read et al, 2013). The first checklist, CHECk 1, focuses on examining values by asking six questions to be answered prior to any design activity. The questions challenge the designer or researcher to consider the appropriateness of both the technical solution and the involvement of children. The aim is to become more explicit about the values that drive the work, pushing designers and researchers to the extremes of honesty.

The second checklist, CHECk 2, aims to examine the value of participation to the child design partners. Child design partners should be informed about what they will be doing during the design activities, how their contributions will be disseminated and, although difficult, who has credit for the ideas they come up with during these design activities. The main goal of CHECk 2 is achieving ethical symmetry, that is, full consent from the children instead of only consent by adults (Christensen and Prout, 2002). By answering the questions, designers and researchers can make sure children can understand their research.

In this paper, we will investigate CHECk's effectiveness to facilitate critical reflection about ethical issues in CCI and to achieve ethical symmetry in Participatory Design sessions with children. Furthermore, by complementing CHECk with interactive storytelling and creating a shared narrative space were adults and children can meet, we will explore how the tool can be used as a starting point not only to inform but also to negotiate values with child design partners.

7.2.4 Case study

Our study consisted of two parts. Firstly, the first author of this paper performed an expert critique of the CHECk tool. Reflections were discussed in follow-up iterations with the co-authors. Based on the results of the expert review, an extended CHECk tool was suggested. Secondly, the extended CHECk tool was empirically evaluated in a concrete case study that dealt with the design of tangible, digital tools to foster pro-social behavior off- and online within a class group. More particularly, the goal was to strengthen social cohesion and prevent (cyber-) bullying. Data were gathered in co-design sessions that took place in two schools in Flanders, Belgium, with a group of 49 children aged 9 to 10.

7.2.4.1 Reviewing the CHECk tool

The results of the expert review on CHECk identified both strengths and opportunities for improvements. Although CHECk was judged to be a useful tool for examining values and participation prior to and at the start of design activities with children, we also identified four challenges that can be tackled to exploit the full potential of the tool.

Firstly, CHECk focuses on what to tell child design partners but no explanation is given on how to best tell it. This is an important issue since the CHECk tool aims to facilitate a better understanding by children about what the project is about and how they will be involved and contribute to it. Therefore, one should carefully consider in what form to bring the information to the children.

Secondly, designers and researchers involved in a project do not necessarily have a shared point of view. A distinction should be made between values that are explicitly supported and adopted in a given investigation or project and designer or researcher's personal values (cf. self-disclosure) (Borning and Müller, 2012). Designers and researchers also bring values to the design process through seeing as and through making design judgment (Iversen et al, 2010). These personal values do not necessarily correspond with the more general project values.

Thirdly, designers and researchers do not necessarily have a fixed point of view about the project. Their values may be dynamic, they can change as part of the design process due to interactions with other stakeholders as well as the technology being developed, and several viewpoints may co-exist depending on the context (Halloran et al, 2009; Iversen et al, 2010; Manders-Huits, 2011). The use of groups in Participatory Design furthermore reflects a theoretical commitment to the notion that meanings are socially and collectively produced (Buckingham, 2009). Therefore, CHECk, as an ethical probe, should account for changes in values about the project and the technology being developed.
Lastly, CHECk does not fully account for children's values. Only researchers and designers are prompted to examine their values prior to any design activities. Child design partners on the other hand are not given the opportunity to express their values on participation or to negotiate their views on ethical questions such as ownership of ideas. We suggest that, in order to develop ethical practice in Participatory Design with children, dialogue is required, not only between researchers but also between researchers and child design partners
We argue that interactive storytelling may offer interesting opportunities for the challenges listed above and in particular for how to bring the information to the children and how to account for children's values. Building a story around the design challenge and making the project more tangible by adding persona like characters and a realistic plot may be useful for increasing involvement and helping children better understand the value of participation. Establishing a shared narrative space between adults, as outsiders to children's life-world, and children, creates a common ground to meet on (Bekker et al, 2003; Dindler et al, 2005). When telling the story, children should be prompted to reflect on the design challenge, the values at stake and the consequences of participation. This way, the narrative becomes a stepping-stone to open up dialogue with child design partners. Giving a voice to children who are typically not consulted in research practices and ethical considerations may destabilize existing power structures (Vines et al., 2013).
In sum, the expert review has revealed four areas for improvements to extend CHECk 1 and 2: (1) considering how to inform children on the research and their role herein, (2) distinguishing between project values and designer or researcher's personal values, (3) accounting for the dynamic nature and social constructedness of values in design, and (4) the emergence of values in all stakeholders including child design partners. We advocate complementing CHECk with interactive storytelling and using this narrative to not only inform participation and achieve ethical symmetry, but also to negotiate values with our child design partners (Christensen and Prout, 2002).

7.2.4.2 Answering the CHECk questions

In accordance to the CHECk protocol (Read et al, 2013), we answered the questions of the two checklists.

CHECK 1 questions

What are we aiming to design?

Tangible, digital tools to stimulate pro-social behavior, off- and online, within a class context to prevent (cyber-) bullying from happening in the first place.

Why this product?

- Excuse: Bullying behavior, off- and online, is still a widespread problem often related to existing social contexts such as the class group. Since (cyber-) bullying is a group process in which bystanders play an unmistakable role, we target the whole class as a particular social group.
- Honest: We had to choose a target group and a societal problem within an ongoing project. Since preventing and coping with (cyber-) bullying is a hot topic in Flanders and abroad, we saw interesting academic opportunities.

What platform or technologies are we planning to use?

Not yet decided, but our aim is to develop tangible, digital tools that can be used in and around the classroom throughout the year.

Why this platform or technology?

- Excuse: tangible interaction offers interesting opportunities to bridge the gap between the off- and online world of children, and to stimulate pro-social behavior on both levels. Furthermore, tangible, digital tools can easily be embedded in a classroom for structural use throughout the year.
- Honest: we wanted to do something with tangible interaction, since it offers more possibilities from a technological innovation point of view compared with a mobile application.

Which children will we design with?

Fourth graders (i.e. 9- to 10-year-olds) living in Flanders Belgium.

Why these children?

- Excuse: According to literature, 9- to 10-year-olds are an interesting target group for prevention due to the growing influence of peers and the early uptake of social media.
- Honest: One of the researchers involved in the project was looking for an additional case for his PhD research. Therefore, we chose the exact same target group.

CHECk 2 questions

Why are we doing this project (i.e., summary of CHECK 1)?

By designing tangible, digital tools to foster pro-social behavior off- and online within a class group, we hope to prevent (cyber-) bullying. The societal relevance of the problem provides interesting academic opportunities. Also, tangible interaction is an interesting topic from a technological innovation point of view. Finally, 9- to 10-year-olds are an interesting age group for prevention and this target group could also be aligned with an ongoing PhD research.

What do we tell the children?

We are looking for ways to enhance the class atmosphere and to make sure everybody gets along. We therefore aim to build some kind of technology that you, the children, can use in and around the class throughout the year.

Who is funding the project?

IWT, the Agency for Innovation by Science and Technology in Flanders, Belgium.

What do we tell the children?

We are researchers working at the University of Leuven, this means the university pays us to do research.

What might happen in the long term?

By means of multi-modality analysis we will analyze and interpret the results (i.e., artifacts and explanations). The results will be taken forward to fuel the design process and complement the viewpoints of adults. The final design may be implemented in different schools and released in the market.

What do we tell the children?

Some of your ideas may actually be used but most likely not just one idea but a mix of different ideas from you, the children, as well as ideas from parents, teachers, etc. With all these ideas in mind, we will invent something that we might sell to schools throughout Belgium.

What might we publish?

Reflections on methodology and results of the Participatory Design activities with children.

What do we tell the children?

We will write about the activities we will be doing together and the ideas you come up with during these activities. These writings will be published in specialist magazines.

7.2.4.3 Extending CHECk with a storyline

In the case study, we aimed to evaluate the suggestions for improving the CHECk tool that followed from the expert evaluation. To realize this, we extended CHECk with an interactive storyline. As a starting point for our narrative, we used the results of CHECk 2. The first part of the narrative was about us, about what it means to be a design researcher. The second part contextualized the design challenge by telling a partly fictional story about a schoolteacher, Miss Anneleen. The 23 9-10-year-old boys and girls in her class are having a difficult time. The children don't get along very well and the atmosphere in the class is below zero. A lot of detailed examples were included in the narrative, such as: "Some children always play together during breaks, while excluding others who would really like to join them."

The teacher tried many things to change the atmosphere for the better, but without success. Therefore, she contacted her brother, a researcher at the university, and asked him for help. Since the brother did not know what to do either, he decided to ask children in other schools to help him solve the problem of the bad atmosphere. Together with these children and a colleague he wants to invent something magical to be used in class to enhance the atmosphere and the team spirit. With this story, our aim was to establish a common ground to meet on and to provide a clear end-goal.

7. 2. 4. 4 Negotiating values

The narrative became the leitmotif of the design activities with children. In total 4 design sessions were arranged with the children over a number of weeks. During this first meeting, we also gave the children a sensitizing package (Sleeswijk Visser et al, 2005) with four assignments. Unfortunately there is no room to elaborate on each of the assignments, but in one of the assignments we asked them to draw a class with a bad atmosphere, a class they definitely don't want to be part of. This was an individual assignment carried out at home. The results of this were then used to inform the narrative within the second design session. This way, the design challenge became much more tangible and tailored to children's world, creating feelings of ownership and a better understanding of the problem.

When we met the children for the first time in their classroom, we did not tell the story in a one-way fashion. Rather, we combined it with an interactive introduction about us, being researchers and what that means. We asked the children what they think it is that researchers do and why. Next, we introduced the problem of Miss Anneleen and we asked the children about their opinions. We then revealed the purpose of our visit, being asked by Miss Anneleen to help her solving the problem of the bad atmosphere in her class and that we needed their help. Some children were a bit skeptical in the beginning and wondered if the story was real. However, because of the many details and the story's realism, the children got excited right away.

Next, we used the answers of CHECk 2 to negotiate and inform participation. We asked questions such as "What should we do if our ideas actually solve the problems in Anneleen's class?" and "What if we earn money with an invention based on our ideas?" Formulating these and other questions, we tend to use our and not your ideas, since the designer or researcher facilitating the activities will actively contribute as well. These questions evoked interesting debates, for example between a boy wanting to buy a PlayStation for class use and a girl proposing to use the money to help children in other schools. Girl: "I think, that uh, we should use the money to help children in other schools as well, and so, that the class atmosphere can improve their as well, in all schools in Belgium."

While making these suggestions, children's values were implicitly expressed. Some of the children's opinions notably changed during the discussions with their peers and the researchers. When we finally proposed to use the money, if we would make any money at all, for additional research on the topic they simultaneously yelled "Yes!". In other words, an overall consensus was reached. Instead of being passive listeners, the children behaved as active participants from the very start. Due to this process, feelings of problem ownership emerged and children gradually uncovered and identified their personal values. This is considered to be an important step for building mutual trust between adults and child design partners. These values were documented by writing down children's reactions and by making a report immediately afterwards.

7.2.5 Reflections and conclusion

Complementing CHECk with interactive storytelling has been shown to be an effective way as to how to inform participation and achieve ethical symmetry, but with it came new challenges. The subtle paradox of using a half lie (i.e., a made up story) to strengthen ethics and transparency in Participatory Design with children and the question of how to control the risk of possible influences from researchers on children's answer for final consensus should both be topics for further research.

Besides these challenges, interactive storytelling enabled us to create a shared narrative space. The shared narrative became the leitmotif, structuring the design activities and providing a clear end-goal for our child design partners. Since the story was fueled by children's input, it became tailored to their life-world, creating feelings of problem ownership and mutual trust.

By constantly probing children to think about and discuss their underlying motives (e.g. a group discussion about ownership of ideas, why questions embedded in drawing assignments, etc.), children's values emerged and developed recursively. Although CHECk was intended as an ethical probe to be used prior to and at the start of design activities, it became a vehicle for eliciting and negotiating values throughout the project.

7.3 Challenging group dynamics in Participatory Design with children: Lessons from Social Interdependence Theory

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7.3.1 Abstract

In this paper we explore whether Social Interdependence Theory (SIT) is a useful theoretical framework to anticipate on challenging intragroup dynamics in co-design with children. According to SIT, there are five principles that mediate the effectiveness of cooperation: positive interdependence, individual accountability, promotive interaction patterns, social skills and group processing. First, we theoretically ground six challenging group dynamics encountered in a previous study. Next, we introduce SIT and describe how we applied each of the five mediating principles in a new case study in which 49 children aged 9 to 10 were involved in a series of co-design sessions. Afterwards, we present our findings and reflect upon the SIT inspired co-design procedure. Finally we touch upon topics for further research and we make a call for more research on SIT in the Child Computer Interaction (CCI) community.

Categories and Subject Descriptors

H.5.2 User Interfaces, Theory and methods, User-centered design

General Terms

Design; Performance

Keywords
CCI; Co-design; Group dynamics; Social Interdependence Theory; Children; Participatory Design

7.3.2 Introduction

Within the area of Child Computer Interaction (CCI) children have participated in the design of technology for over two decades, relying on a variety of established methods. Whereas some researchers have involved children primarily as technology testers (e.g. Zaman and Vanden Abeele, 2010; Sim and Horton, 2012, others have included children to inform the design process at certain stages (e.g., Scaife and Rogers, 1999; Duh et al, 2010) or as full participants to give children an equal saying throughout the design process (e.g., Dindler et al, 2005; Druin 2002; Garzotto, 2008; Göttel, 2013; Guha et al, 2013). These methods typically involve children in dyads or groups, rather than individually. For instance, Hoysniemi and colleagues (2003) relied on peer tutoring (children teaching other children software use) to evaluate software products. Moser and colleagues (Moser et al., 2014) involved preteens in game design via ideation workshops. Druin (2002) formed intergenerational design teams in which children and adults worked together for a prolonged period of time. Read and colleagues (2014) involved teenagers in a series of Participatory Design activities in schools. Involving children in dyads or groups can be argued from a theoretical commitment to the notion that meanings are socially and collectively produced (Buckingham, 2009).

Positioning children as design partners of their technology and of the practices that may be reified in that technology, is in line with Participatory Design (PD) (Bjerknes et al., 1987). PD is commonly defined as a collection of theories, practices and methods that facilitate end-users' or other stakeholders' participation in the design process of technological artifacts or services (Muller, 2002). PD originated in the Scandinavian labor movement in the 70s and 80s and was motivated by a commitment to empower workers and fostering democracy in the workplace (Spinuzzi, 2005). Since then, PD has achieved a status as a useful approach to developing better products. Involving stakeholders, including potential end-users, is believed to give better insights, which could not have surfaced otherwise. However, in this discourse, PD is often framed as simply a design method to optimize the outcome, i.e. a user-friendly solution.

Recently, attempts have been made to rekindle values in what is called a more authentic approach towards PD (Iversen et al, 2010; Halloran et al, 2009). Iversen and colleagues (Iversen and Smith, 2012) for instance, have proposed a PD approach to go beyond developing a final design outcome and to establish an ongoing dialogue with children. Their approach serves a dual purpose: providing children with meaningful alternatives for existing technology and helping children realize that they do have a choice when it comes to the design of future technologies. Their approach requires a highly dialogical process that goes beyond merely collecting user needs and requirements. During design activities, children's values are implicitly or explicitly expressed as something children care about and find important in life (Rokeach, 1973). Children's values do not progress stepwise, but rather emerge, develop and ground recursively and dialogically over the course of the design process (Iversen et al, 2010). To engage with values in PD, a core task for design researchers is to orchestrate this dialogue with and among children in order to ensure value conflicts are transcended and translated into meaningful design concepts. Special attention should thereby be given to group dynamics that may impact this dialogical process.

Within the CCI community, authors have only recently started to acknowledge the importance of group dynamics in PD with children (e.g., Vaajakallio et al, 2010; Dodero et al, 2014). Facilitating group dynamics is believed to have a positive impact on children's motivation as well as on the development of creative solutions (Cross and Cross, 1995). Nevertheless the concept group dynamics has generally been poorly defined within the field of CCI. When defined, the majority of CCI-research has focused on remediating asymmetrical power relationships between adults and children (e.g., Druin, 2002; Guha et al, 2013; Mazzone et al, 2010). However, dynamics among children themselves are neglected.

In previous work (Van Mechelen et al., 2014a) we addressed this gap in research and presented an in-depth exploration and categorization of challenging group dynamics when co-designing technology with children. We thereby referred to co-design dynamics as "a system of behaviors and psychological processes within a group of children sharing a common and often imposed design goal" (Van Mechelen et al., 2014a). However, we did not yet propose any solutions. Therefore, in this paper, we continue our work by looking for ways to anticipate on these challenging intragroup or co-design dynamics. More particularly, we will show that by applying the key principles of Social Interdependence Theory (SIT) to Participatory Design sessions with children, we can remediate challenging group dynamics into positive forces that give rise to improved collaboration, increased ownership and more focused results.

In what follows, we will first briefly summarize and theoretically ground the challenging dynamics encountered. Afterwards, we will describe SIT's history and key principles, and we will illustrate how we applied these principles in a series of co-design sessions with 49 children aged 9 to 10 to better structure cooperation. Finally, we will discuss and reflect upon our findings and topics for further research.

7.3.3 Co-design dynamics

The term group dynamics was first coined by social psychologist Kurt Lewin (1948) and refers to a system of behaviors and psychological processes occurring within a social group (i.e. intragroup dynamics), or between social groups (i.e. intergroup dynamics). In this paper, we refer to co-design dynamics as a system of intragroup dynamics occurring within a group of children sharing a common and often imposed design goal.

Although not a complete list, we revealed six challenging co-design dynamics (Van Mechelen et al., 2014a) referred to as Unequal Power (i.e., some children come to the co-design tasks with higher status than others), Free Riding (i.e., reduced effort by some individuals when working in a co-design team and taking advantage of other team members), Laughing Out Loud (i.e., an unwillingness to take the task at hand serious as a group), Dysfunctional Conflict (i.e., escalating disagreements leading to a polarization within the team), Apart Together (i.e., working individually and only combining results superficially), and Groupthink (i.e., poor decision-making by rushing too quickly towards consensus, neglecting choice alternatives) (Van Mechelen et al., 2014a). Most of these challenging dynamics are well known in group dynamics research (e.g., Sawyer, 2008; Sutton and Hargadon, 1996; Franz, 2012) but have rarely been addressed in the field of CCI and in literature on co-design. In what follows, we will briefly describe each of these dynamics and provide more theoretical grounding.

7.3.3.1 Unequal Power

Some co-design teams quite openly follow the opinions and ideas of a dominant or charismatic team member. Such a leading member enjoys a higher status in the co-design team and can exert tremendous influence on the group process, either positively or negatively. This type of power is referred to in literature as personal power and in co-design usually results from liking, respect and admiration of other team members and/or the belief that one holds credibility or expertise (Franz, 2012). High-power children have a higher likelihood of swaying any final decision by direct or indirect pressure as well as through the time they are allotted for discussion. By misusing their personal power, they can capitalize on the situation and force their design ideas on the team. This makes it difficult for less verbal and/or shy children to voice their opinions, and limits their influence on the group, thus undermining team effectiveness (Van Mechelen et al., 2014a).

7. 3. 3. 2 Free Riding

Not all children devote equal effort when working in a team. Some children may take advantage of the work of others, because they feel not as responsible to contribute. This dynamic is well known in social psychology as Social Loafing, that is, "the tendency for individuals to expend less effort when working collectively than when working individually" (Karau and Williams, 1993). Free Riding is a particular kind of Social Loafing where team members decide to let others contribute and choose not to fully participate (Sutton and Hargadon, 1996). In co-design, loafing practices such as Free Riding cause reduced performance because not all children are working at their full potential. In addition, loafing may result in tensions and conflicts between children because it reduces feelings of satisfaction, and those group members who do not loaf feel that they have been taken advantage of (Franz, 2012).

7. 3. 3. 3 Laughing Out Loud

Co-design teams sometimes gang up on the task. They are having a good time, but there is an unwillingness to take the task at hand seriously. In such teams, the atmosphere turns out to be disruptive rather then constructive. This may be due to a lack of intrinsic motivation and problem ownership, because children cannot identify a problem space they feel is worth tackling as a group (Halloran et al, 2009). This tendency towards an unserious atmosphere is often a gradually evolving process. At the beginning of a co-design session, only one or two group members may be giggling and come up with rather silly and irrelevant ideas. After a while, this behavior becomes viral and affects the other team members. The group ends up in a state of full immersion in the unserious behavior, and their priorities have shifted from finding a design solution to having a good time (Van Mechelen et al., 2014a).

7. 3. 3. 4 Dysfunctional Conflict

Different types of conflicts may occur during co-design. Whereas some conflicts are caused by personal incompatibilities, others are task-oriented (disagreement about what should be done) or process-oriented (disagreement about how it should be done) (Jehn, 1997). For instance, some children may have a difficult time letting go of their initially chosen ideas (task conflict). This may complicate negotiating ideas with other team members and lead to disagreements about how to select ideas after ideation (process conflict). Children are not always capable of managing such conflict or differing voices productively, leading to a polarization within the team. Although moderate amounts of process and task conflict may be essential to move teams towards creative breakthroughs, it must be managed. If not, conflict easily becomes destructive, causing defensive behavior, inflexibility, contempt, a lack of trust and an unwillingness to work together (Franz, 2012).

7. 3. 3. 5 Apart Together

In some teams, children do not build on each other's ideas and follow their idiosyncratic interests. Instead of working toward one integrated design, only in the end they combine their individual designs superficially. As a result, the groups' designs are a disconnected mix of individual designs, lacking an overall design vision. In such groups, collaboration often falters due to a lack of cohesion, or "the glue that makes the members of a group stick together" (Nelson and Quick, 2008). Children may experience a lack of commitment to the group goal (task cohesion) or a lack of affect towards team members (social cohesion) and therefore decide to work individually rather than to collaborate and make design decisions together (Myers and Anderson, 2008). Another cause of the Apart Together dynamic is a lack of interpersonal and small-group skills, necessary for high-quality cooperation in co-design with children.

7. 3. 3. 6 Groupthink

The dynamic of Groupthink usually occurs in teams with high group cohesiveness. When everybody gets along, members often see the group as more effective than it really is (Sawyer, 2008). Psychologist Irving Janis (1982) coined the term Groupthink to describe a phenomenon in which the group ends up being dumber than its individual members (Janis, 1982). In co-design, children may sometimes be reluctant to criticize the ideas of others in the team to safeguard the positive atmosphere. As a consequence, they keep on adding functionalities to please every team member and eventually end up with a design bloated with features. This emphasis on concurrence seeking instead of fully surveying choice alternatives leads to poor decision-making (Franz, 2012). For creative breakthroughs to emerge, more energy should be created around sharing diverse information and viewpoints to move groups from Groupthink to group genius (Sawyer, 2008).

7. 3. 3. 7 Managing intragroup dynamics

The six dynamics described above are often linked. A team may fall into the Groupthink trap when group cohesion is high and the team lacks diversity (i.e., differences in skills, abilities and backgrounds) (Franz, 2012). A dominant child may further strengthen Groupthink by imposing ideas (Unequal Power dynamic), upon which the team agrees too soon without critical examination of other choice alternatives. Such teams could actually benefit from a moderate form of conflict for creative breakthroughs to emerge. Although conflict is often perceived as a negative force, with cooperation at the other end of the continuum, the impact on group performance is more nuanced than that. Conflict can be a positive force when it creates more energy around sharing diverse information and viewpoints. The challenge is to move groups from dysfunctional to constructive conflicts.

Whereas some teams could benefit from a moderate form of conflict, the opposite holds true for teams that are hesitant in making design decisions together and only combine individual efforts superficially (Apart Together dynamic). Whereas this behavior may be a strategy to avoid further escalations within the team, it prevents the team from reaching its full potential. These teams usually lack both task and social cohesion and the main reason why the team is not disbanded is because the children are imposed to work together. Whereas the Groupthink dynamic is often caused by a lack of diversity in the team, diversity can be a double-edged sword. Though diversity is positively correlated with creativity and performance, at the same time it has the potential to reduce group cohesion (Shapcott et al., 2006). In teams with little cohesion, loafing practices such as Free Riding are much more common, because the team members feel not as motivated and accountable to contribute.

Clearly, managing intragroup or co-design dynamics is a question of finding the right balance. In co-design, collaboration may lead to more creativity and unexpected concepts children could not have come up with alone. However, as Sawyer (2008) puts it: “Putting people into groups isn’t a magical dust that makes everyone more creative”. Teamwork entails resolving a paradox between providing enough focus, and leaving room for problem-finding to occur (Sawyer, 2008). Whereas a well-defined design goal may increase (task) cohesion and provide focus, leaving room for problem-finding may increase feelings of ownership and personal responsibility (Sawyer, 2008).

When intragroup dynamics are not managed properly, one child’s freedom may easily become another child’s lack thereof, which undermines team effectiveness in co-design. Social Interdependence Theory offers interesting guidelines to anticipate on these challenges and structure cooperation more efficiently. Below, we will briefly discuss the theory and afterwards we will illustrate how we applied the theory’s principles in a series of co-design sessions with children.

7.3.4 Social Interdependence Theory

In this section we will summarize Social Interdependence Theory (SIT) and place it in a historical perspective. SIT provides a conceptual framework to organize thinking about cooperation and competition (Deutsch, 1962; Johnson and Johnson, 2005). The theory states that the manner in which social interdependence between individuals is structured, determines how these individuals interact, which, in turn, determines outcomes. Social interdependence exists when the outcomes of individuals are affected by each other's actions, either positively, when the actions of individuals promote the achievement of joint goals (positive interdependence), or negatively, when there is a negative correlation among individuals' goal attainments such as in a competitive situation (negative interdependence). Social interdependence should be differentiated from social independence that exists when the goal achievement of one person is unaffected by another person's actions and vice versa.

SIT has its origins in Gestalt Psychology (Koffka, 1935) and Lewin's Field Theory (1948), was formally conceptualized by Deutsch (1949) and extended by Johnson and Johnson (2005; 2009). For Gestalt Psychologists, the whole or gestalt is the focus of attention when studying perception and behavior. Gestalt Psychologists argue that, in order to make meaning of their world, humans perceive events as integrated wholes rather than as the sum of its parts or properties (Koffka, 1935; Johnson and Johnson, 2009). Similarly, groups are seen as dynamic wholes in which the interdependence among members could vary.

Building on the principles of Gestalt Psychology, Lewin (1948) defined the perceived interdependence among group members as the essence of a group. Groups, according to Lewin, are dynamic wholes in which group members become interdependent through common goals. When group members perceive their common goals, a state of tension arises that motivates them to accomplish these goals (Lewin, 1948). Deutsch (1962) extended Lewin's notions by studying the interrelation between tension systems of different people. The basic premise of Deutsch' SIT is that the structure of the goals of the people in a situation, determines how people interact, which in turn determines the outcome of that situation. For instance, in a competitive situation individuals can only obtain their goals if the individuals with whom they are competitively linked fail to reach theirs. The opposite holds true in a cooperative situation.

Johnson and Johnson modified and extended Deutsch's SIT by identifying and validating five principles that mediate the effectiveness of cooperation and competition (Johnson and Johnson, 2005; 2009). The combination of these principles, argued by Johnson and Johnson, is essential to structure cooperation.

These principles are:

- Positive interdependence: the perception of team members that they have to work together to accomplish a common goal. Team membership in itself is not sufficient for higher achievement and productivity, positive interdependence is also required. This way, team members perceive that their work is important to the entire group.
- Individual accountability: assessing individual performances and holding team members responsible for doing their share in achieving the mutual goal. Individual accountability leads to feelings of responsibility among team members for completing their share of the work and facilitating the work of others in the team.
- Promotive interactions: face-to-face meetings between team members to encourage and facilitate each other's efforts to accomplish the group goals. Positive interdependence tends to result in promotive interactions between individuals, strengthening caring and committed relationships. Negative interdependence, on the other hand, leads to oppositional or contrient interactions.
- Appropriate use of social skills: team members need appropriate interpersonal and small-group skills (e.g. active listening and good questioning) as well as the motivation to use them. Social skills are essential to cope with the stresses and strains of working in a team and are a precondition for promotive interactions to occur.
- Group processing: team members reflecting upon the group process and making decisions about which actions to continue or change. To continuously improve their work over time, teams need time to discuss how well they are achieving their goals and maintaining effective working relationships among members.

Since its original formulation by Deutsch (1949) and its extension by Johnson and Johnson, SIT has been widely applied, especially in business and education. These applications have resulted in considerable new research on SIT's effectiveness. A critical analysis of this extensive research showed a high external validity and generalizability (Johnson and Johnson, 2009). However, applying SIT in co-design with children is unprecedented. In the next section we will show, via a case study, how we applied SIT's five mediating principles in co-design with children to address challenging co-design dynamics.

7.3.5 Case study

We applied the key principles of SIT in a case study in which 49 children aged 9 to 10 were involved in a series of co-design sessions in two schools in Flanders, Belgium. The sessions were part of a project aimed at the design of tangible, digital tools to make class groups more self-regulatory in the prevention of both traditional bullying and cyberbullying. In what follows we will elaborate on the different steps of the co-design procedure and how we applied SIT's mediating principles. In section 4 we will reflect upon the use of SIT in co-design with children to improve collaboration and remediate challenging intragroup dynamics.

7. 3. 5. 1 SIT inspired co-design procedure

We used a blend of two different approaches to co-design: Cooperative Inquiry (Guha et al, 2013) and Contextmapping (Sleeswijk Visser et al, 2005). The basic principle of both approaches is to let people make designerly artifacts and tell a story about what they have made (Sanders, 2000; Sleeswijk Visser et al, 2005). Over a period of one month, two co-design sessions were organized in two primary schools preceded by a general introduction, resulting in three visits per school (see Figure 33). Two researchers were involved in each co-design session and the introduction: one facilitator who interacted with the children and

INTRODUCTION & SENSITIZING

Goal: reflection and understanding

CO-DESIGN SESSION 1

Goal: team cohesion and problem ownership

- Group formation and distributing roles
- Teambuilding and empathy exercise
- Problem definition
- Presentation and discussion
- Group processing

CO-DESIGN SESSION 2

Goal: problem solving and evaluation

- Ideation and selection
- Elaboration through making
- Peer jury
- Group processing
- Wrap up

Figure 33: The different steps of the SIT inspired co-design procedure

one fly on-the-wall observer making notes. In addition, the sessions were recorded on video and a report was written immediately afterwards. The general introduction took about 45 minutes per class group, whereas the co-design sessions lasted for about 150 minutes each. The co-design procedure to which we applied the key principles of SIT will be described in the next paragraphs.

Introduction and sensitizing

When we met the children for the first time in their classroom, we explained the reason for our visit and told them that their help was much appreciated. The children had to find out through a question and answer game that we were researchers and what that means. Next, we introduced the design challenge: "What (digital) tools could primary school children use to improve the class atmosphere and thus prevent bullying?" To make the design challenge more tangible, we used a fictitious, detailed story of a class with a negative atmosphere as a starting point. For more information on the use of storytelling in PD with children, we refer to (Van Mechelen et al., 2014b). With this story, our aim was to create a sense of positive interdependence among children by providing the teams with a clear purpose. This specific type of positive interdependence is referred to as outcome interdependence in SIT and may result in increased achievement and productivity (Johnson and Johnson, 2009).
During our first encounter with the children we furthermore introduced a sensitizing package with four individual assignments. The goal of these assignments was to trigger children's reflection in a playful and creative way, and to prepare them for the co-design sessions approximately two weeks later. Children had to work on these assignments at home in their free time. One assignment was to draw a class with a bad atmosphere and to specify reasons why they would not want to be in that class. In another assignment, children were asked to interview (one of) their grandparents about what school was like when they were the child's age. For more information on sensitizing we refer to (Sleeswijk Visser et al, 2005).

First co-design session

The goal of the first co-design session was to create cohesive teams and, for each team, to define two problems based on the story and design challenge. In the second session, each team would then invent something to solve these problems.

Group formation and allocating roles

Each class group was divided in a morning- and afternoon group. At the beginning of the co-design session, these morning- and afternoon groups were split into three gender-mixed subgroups of four to six boys and girls. With the help of the children's teachers, these subgroups were formed heterogeneously, based on criteria such as intelligence, communication skills, gender and creative abilities. Forming groups heterogeneously may result in a broader subset of complementary skills per team, which, in turn, increases interdependence (Johnson and Johnson, 2005). Teams were seated in different corners of the room and although they could walk around, they were asked to stick to their team. Proximity (e.g. being seated together) is an efficient way to structure boundaries between individuals and groups so as to define who is interdependent with whom. This type of positive interdependence is referred to as boundary interdependence (Koffka, 1935; Johnson and Johnson, 2009).

After discussing the purpose of the co-design session, the researcher reiterated the story of the class with a bad atmosphere, but now with additional details. For instance, a situation was described in which a girl made fun of someone's appearance. Next, the researcher introduced different roles to be distributed between the team members. Each role came with a specific responsibility translated in a set of class rules to which we referred as rules of the game. The material guard was responsible for the use of the materials and had to make sure each group member had something (e.g., scissors, glue, etc.) to work with. The silence captain had to assure the children were quiet when the researcher would explain the next step. The responsibility of the inspiration general was to assure that each child had an equal chance to contribute and that nobody would impose his or her ideas. The fourth and last role was that of the timekeeper, who had to prevent the co-design team from running out of time before completing the tasks. Our hope was that the responsibility associated with each of these roles would make group members accountable for doing their share of the work. According to SIT, increasing individual accountability will, in turn, increase perceived interdependence among team members, creating a snowball effect within the team.

Badges visualized the roles (see Figure 35). Teams were asked to think carefully about which role was best suited for which team member and to assign the badges accordingly. This negotiating process allowed children to practice interpersonal and small-group skills needed for high-quality cooperation. These skills include communicating accurately and unambiguously and resolving conflicts constructively (Johnson and Johnson, 2005; Johnson and Johnson, 2009).

Teambuilding and empathy exercise

The next phase included an introductory design activity. To strengthen the teams' cohesiveness, we asked the children to think of a group name and design a logo (see Figure 34). For this activity, which was relatively easy compared to the project's design challenge, the children had to pay special attention to their roles and ditto responsibilities. When all teams were ready, they presented their group name and logo to the other teams who could voice their opinions. This way, the co-design teams could get used to communicating ideas and being evaluated by their peers. Knowing this up front may foster feelings of responsibility necessary for high-quality cooperation (Johnson and Johnson et al, 2005; 2009).

The following stage entailed an empathy exercise. Therefore the researcher handed out the results of one of the sensitizing assignments in which the children had to interview their grandparents about school life when they had their age. We asked them to discuss with their team members how school life had changed since then. Our hope was that children would

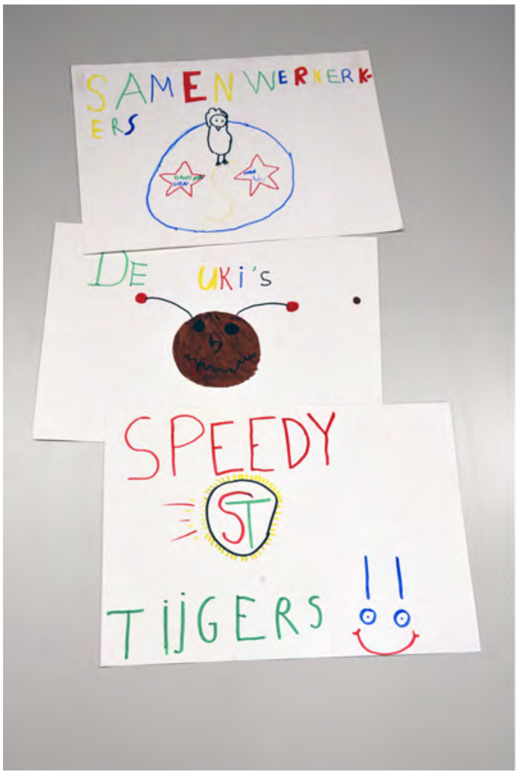

Figure 34: Logo designs (left) - Figure 35: Badges for the different roles: material guard, silence captain, inspiration general, time keeper (right)

approach the design challenge in new and unexpected ways due to this empathy exercise. At the same time, these discussions offered another opportunity to practice social skills before the teams would move on to the next step: problem definition.

Problem definition and discussion

Each co-design team received a card with the story describing a class with a negative atmosphere, including detailed examples. The design challenge embedded in the story (i.e., improving the class atmosphere) was deliberately kept broad, because we wanted each team to redefine the design challenge based on their interpretation of the story. We aspired that this would lead to increased problem ownership and involvement throughout the co-design sessions. Afterwards, the teams were asked to make a collage on a big sheet of paper that would illustrate the negative class atmosphere in the story (Figure 36). They could use different materials (e.g., markers, all sorts of pictograms, colored paper, etc.), but some of the materials were limited to one piece per team (e.g., scissors and glue). Limiting materials may be another way to increase interdependence because it forces teams to think carefully about who does what and in which order. This type of positive interdependence is referred to in SIT as means interdependence. While making the collage, the children were again prompted to focus on their role and responsibility so as to avoid Free Riding whereby some group members let others do all the work.

Next, each team picked six situations they had just visualized and discussed why each of these situations negatively influenced the class atmosphere. When a consensus was reached, they wrote their arguments on sticky notes and attached them to their collage. They then had to pick two problematic situations for which they would invent a solution during the next co-design session. Finally, each team briefly presented their collage to the other groups. Both the researcher and the children could ask questions. As noted earlier, when a team's performance is being assessed, feelings of responsibility and group accountability may be increased (Johnson and Johnson, 2005; 2009).

Group processing

At the end of the co-design session we asked the teams to evaluate the collaboration process. They had to list three actions that were helpful to accomplish the team's goals, and one action that could be added or changed to make the group even more successful during the next co-design session. Group processing allows the co-design teams to improve their work together continuously over time and it focuses attention on team members' contributions in order to increase individual accountability. As argued by Johnson and Johnson (2009), group processing is of uttermost importance to improve the collaboration process, because children will not learn as much from experiences they do not reflect on. When each team had discussed the collaboration process, a class discussion followed. Finally, the researcher explained what would happen during the next session that was scheduled approximately one week from then.

Second co-design session

Ideation and selection

The goal of the second co-design session was to design a prototype that children could use to improve the class atmosphere. Whereas the teams had focused on problem definition during the first co-design session, they were now about to enter the solution space. As mentioned earlier, well-defined goals bind group members together; a type of interdependence that is referred to in SIT as outcome interdependence (Johnson and Johnson, 2009). To refresh the children's memory, the researcher handed out the collages the children had made during the first session. Next, the teams were asked to reallocate the roles and to think carefully about which role was best suited for whom. As in the previous session, the goal of these roles was to increase positive interdependence and accountability.

Afterwards the teams thought of different ideas to solve the problematic situations they had previously selected (i.e., divergence or creating choices). The researcher first introduced the children to the concept of brainstorming. After some classical free association exercises (e.g., through questions as "What pops up in your mind when you think of a birdhouse?"), the teams started brainstorming solutions. The team members had to write each idea on a separate sticky note and put it in the middle of the table to inspire or prime each other (see Figure 36). Priming is an effective strategy for divergent thinking, but may also be useful to engage all members of a group and avoid Free Riding (Johnson and Johnson, 2009). Next, the teams had to group similar ideas together and select two ideas for further elaboration (i.e., convergence or selecting choices).

Elaboration through making

Afterwards the teams elaborated on the selected ideas in a hands-on way. They used the ideas to prototype tools that would improve the class atmosphere. In analogy with mixing two colors into a new color, the researcher explained that the selected ideas could be blended into a new idea. In order to be able to design the tools, the material guard of each team received a bag with all kinds of materials to build the prototype (e.g., scissors, cardboard, glue, aluminum dishes, ropes, colored paper, etc.). To increase feelings of responsibility and individual accountability, the researcher reminded the children to perform their role within the team. To ensure that the teams would discuss their approach and cooperate efficiently, some of the materials they could use were again limited to increase means interdependence. Apart from that, the teams were free to choose how to approach the task at hand.

Peer jury, group processing and wrap-up

For the following phase, the co-design teams had to prepare a presentation about their prototypes (see Figure 37). They could either explain how their solution would improve the class atmosphere or organize a small performance. When one team was presenting, the other teams functioned as a jury. After the presentation, the jury members could ask critical questions and voice their opinions about the prototypes, but in a constructive manner. Finally, each jury member filled in a form with questions such as: "What do you like about the team's invention to improve the class atmosphere?", "Why do you like it?", "If there is one thing you could change, what would be it?" and "Why would you like to change it?".

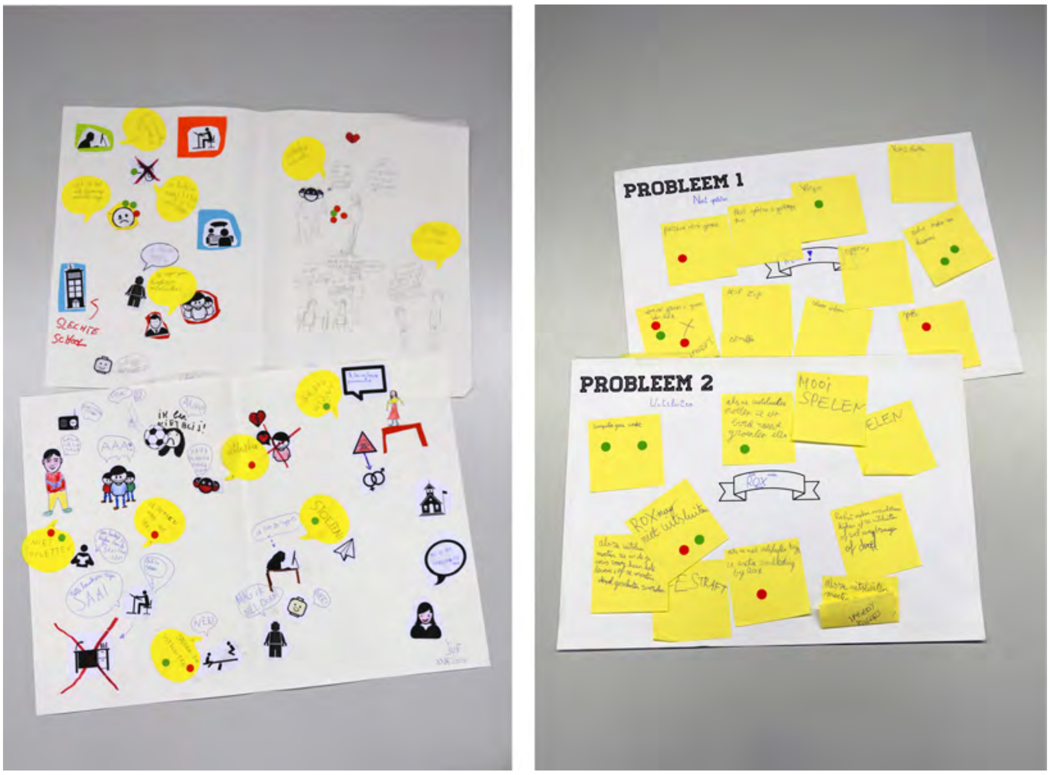

Figure 36: Problem definition collages (left) - Ideation sheets (right)

Peer jurying revealed how children valued each other's ideas. Also, feelings of responsibility and group accountability increased because the children knew beforehand that they would have to present their designs at the end of the session. Presentations and questions were all recorded on video for further analysis. When each team had presented their design, the teams were asked to once more evaluate the group process. At this point, we were especially interested in how the children experienced the use of the roles and the responsibilities associated to these roles, and how the cooperation had changed since the first session. Finally, a short wrap-up followed in which we talked briefly about the next part of our research, and how we would use their designs as a source of inspiration and information.

7. 3. 5. 2 Analysis

The co-design sessions resulted in various tangible (e.g. problem definition collages, co-design prototypes) and textual outcomes (e.g. transcriptions, written ideas on Post-Its, etc.). For the analyses we used a multimodal approach borrowed from social semiotics. For the multimodal analysis of the co-design outcomes, we refer to (Derboven et al, 2015). In this paper, our focus is not on the co-design outcomes but on the cooperation process. More particularly, we aim to explore whether SIT is a useful framework to anticipate on challenging intragroup dynamics in co-design with children. For our analyses, we used detailed observation reports, video fragments and transcripts of the group-processing phase at the end of each co-design session. These data were coded bottom-up, using an open and axial coding approach. In the next paragraph, we describe our findings and reflect upon the SIT inspired co-design procedure.

7. 3. 6 Results and discussion

7. 3. 6. 1 Positive interdependence

Structuring positive interdependence (SIT principle 1) was done in three different ways by (1) providing a clear end-goal and criteria for success through means of storytelling (outcome interdependence), (2) distinguishing groups from each other by separating teams in space, (boundary interdependence) and (3) making team members interdependent through complementary roles and limited resources (means interdependence).

Outcome interdependence

Our results showed that our storytelling approach provided children with a clear end-goal, creating a sense of outcome interdependence. When we met the children for the second time, (1st co-design session) they recalled the story and remembered that they would have to invent something to improve the atmosphere in the class, as described in the story. This suggests that storytelling made it easy for them to understand the design challenge and our expectations. Additionally, storytelling provided focus throughout the preparatory steps (sensitizing, team building and introductory design activities) as well as during the prototyping phase (elaboration through making). This was confirmed by questions of children during the co-design activities, such as:

> Girl: "How many children are exactly in Miss Anneleen's class? We, need to know that for our invention!"

Figure 37: Sprietje, a DJ robot made by team Vivalalalas (left) and a hypnosis machine made by team the Cooperators (right)

Children empathized with the story due to its many details. Our observations suggest that these feelings of engagement and commitment are essential to avoid children from getting caught up in an unserious and disruptive atmosphere (Laughing Out Loud dynamic).

Boundary interdependence

Not all children were happy when we divided them into groups, because they preferred being in the same team as their friends. However, the introductory design activities proved to be an efficient way to reverse feelings of disappointment and strengthen commitment towards the team. For instance, in a team of three girls and one boy, the boy did not seem to have much interest in his team. However, his attitude and commitment towards the team changed when he got involved in the teambuilding activities. He coined the name Speedy Tigers for the team and together they designed an accompanying logo (see Figure 34).

Our results further revealed that, notwithstanding the SIT inspired approach, we could not prevent challenging dynamics to occur. More particularly, in one team named Elcogavi, the teambuilding activities were not sufficient to strengthen cohesion and the Apart Together dynamic was strongly present. In that particular team, children ended up working individually and during presentation it was clear they had not thought profoundly about how their designs could be integrated. In another team, and somewhat related to the Apart Together dynamic, we observed the tendency for boys and girls to work separately. This was the case in team Uki where the boys were responsible for one part of the invention and the girls for another part. They reflected on these gender-based subgroups during group processing:

> Boy: "Uh, finishing in time, we did that well, and uh, that was less good…"
>
> Researcher: "What exactly do you mean? "
>
> Boy: "We have been working in two groups, actually, and we, we laughed a lot."
>
> Researcher: "What kind of groups exactly?" Boy: "The boys and the girls."

However, in contrast to team Elcogavi, Uki's gender-based subgroups eventually integrated the objects into a coherent design. This indicates a division of labor rather than team members working separately without an overall design vision. On the other hand, it shows that teambuilding activities were not always sufficient to transcend gender-based favoritism in teams.

Separating groups in space is another way to create boundary interdependence. In the implementation of this mediating principle, we stumbled upon practical constraints as the amount of physical space between teams varied greatly according to the room we had at our disposal. In small rooms where teams were seated close together, it was harder for children to stick with their group. In one school this led to an exchange of ideas across teams. As a consequence, all three teams ended up designing a robot, be it with different functionalities attached to it.

Means interdependence

Roles

When evaluating the first session, we realized that we did not emphasize in our instructions that the distribution of roles (i.e., inspiration general, time keeper, material guard or silence captain) would imply negotiation among team members to decide which role was best suited for whom. As a consequence, children chose roles randomly, which led to disagreements because some children were not happy with their role. We also grasped that we were not clear enough on the responsibility that came with these roles. During group processing, some children were critical about the function associated with their role:

> Boy: "Mmm, actually I did not know, uh, what a material guard had to do."
>
> Girl: "Me too with the time keeper, because there really was no time, because you did not tell us when it had to be finished, only the first time."

These problems were dealt with in the second co-design session: we stressed that they had to negotiate which role was best suited for whom and we summarized the roles on the badges as a visual reminder (see Figure 3). Moreover, we gave specific tasks throughout the session to make the roles more active. For example, material guards had to distribute sticky notes for ideation and timekeepers had to set a timer when their team was ready for the next task. These simple measures together with the time allotted for practice (i.e., during introductory design activities) proved to be useful. At the end of the second co-design session, the roles had become a second nature to most children. A striking example was an inspiration general proposing to vote ideas anonymously after brainstorming to prevent the team members from imposing ideas on others.

Resources

Limiting materials per team both had positive and negative effects on cooperation. Based on SIT, we expected that limiting materials would enhance communication because team members would have to think carefully about who did what and why. However, we found that limiting materials sometimes encouraged loafing practices such as Free Riding, because children felt they could not contribute to the teamwork. It also led to disagreements about how to distribute the available tools. For instance, cutting out forms was a popular task, resulting in heated debates about who was allowed to use the pair of scissors. Children reflected on this problem during group processing:

> Boy: "That, everyone, yes, could use the pair of scissors in turn and uh, yes, we think there were not enough scissors, because, everybody, yes everybody wants to use it to cut out their own idea and you always have to wait till the other one was finished."

Although SIT suggests otherwise, this observation shows that limiting materials is not always an efficient way to improve cooperation. At the same time, the quote reveals an underlying problem: children being engaged with their own ideas instead of negotiating a solution with their team members. Initially, we dealt with such process conflicts (i.e., disagreements about how to approach a task) by giving extra materials. However, in the long run, this was usually not the best solution, as exemplified in the following quote:

> Girl: "Uh, sometimes, someone took away the pair of scissors when someone else needed it as well, and then we had two pair of scissors and it even got worse."

A more efficient approach was to facilitate children towards a solution without the need for extra materials. This proved to be a worthwhile strategy, because most of the teams showed significant progress in distributing materials and tasks during the second co-design session. This was confirmed during group processing:

> Researcher: "How was the collaboration in your team?"
>
> Girl: "I think the cooperation was good, because together we taught of different ideas together and then, then we divided the tasks, who what, you know, we divided who did what so everybody knew what to do, it was not like, what can I do"

7. 3. 6. 2 Individual accountability

Creating a sense of positive interdependence (SIT principle 1) by structuring outcomes, boundaries and means is posited to result in feelings of responsibility and accountability (SIT principle 2) among team members. As suggested by SIT, the different roles children had to take on were used to increase feelings of responsibility towards the team. Although we did not assess individual contributions, we reminded children of their role within the team to, for instance, successfully counter a case of Free Riding. Our results showed that the roles were not only useful to anticipate on challenging group dynamics, but also to remediate such dynamics on the spot. Moreover, children referred to the roles during group processing to express how they believed the cooperation could be improved. We noticed that by referring to a role rather then to a specific team member, the criticism became less personal.

> Girl: "My wish would be that, for example, the silence captain would make sure there is less noise next time."

Another way in which we succeeded to increase feelings of responsibility towards the team was by letting teams evaluate each other's efforts in the form of a peer jury. We found that peer jurying revealed interesting insights about how children valued each other's ideas, but was also a useful strategy to increase group accountability. Some children became visibly nervous or exited when they had to present their prototype. Even the boldest children clearly wanted to make a good impression on their peers.

Although SIT focuses on individual accountability, our results showed that increasing both individual and group accountability is a worthwhile strategy to improve cooperation in co-design.

7. 3. 6. 3 Promotive interactions

Positive interdependence (SIT principle 1) not only increases feelings of responsibility and accountability (SIT principle 2), it is also posited to result in promotive interactions (SIT principle 3) between team members. According to SIT, whether or not children engage in promotive interactions largely depends on children's social skills and the perceived interdependence in the group. We influenced promotive interactions indirectly by structuring interdependence (SIT principle 1) and training children's social skills (SIT principle 4).

We observed both promotive and contrient interactions. For instance, during the first co-design session, a boy in team Apples was overly enthusiastic, but despites his commitment he did not give his team members an equal chance to contribute and tried to impose his ideas

(Unequal Power dynamic). In team Uki we observed quite the opposite. A girl gradually became more devoted to the teamwork because of the positive feedback she received from her group members. She consequently used her higher status in the group to involve and motivate other team members. This observation shows that, when the conditions are right, promotive interactions can mitigate Unequal Power distribution.

In general, we observed more promotive interactions during the second co-design session. There may be several reasons for this positive evolution. Children gained experience in teamwork through the co-design activities. Additionally, at the end of the first session, children reflected on the collaboration process and how it could be improved. Most teams succeeded in applying these suggestions for improvement throughout the 2nd session.

> Researcher: "How was the collaboration compared with the first session?"
> Boy: "Better! Uh if, for example, if someone made something and then we said 'Should we do this or not?' and then we decided it was okay. But if we, if one person said 'no', then we didn't do it. So if one person didn't find it good we didn't do it; we only did what everybody wanted to do, and I think that's good."

7. 3. 6. 4 Interpersonal and small-group skills

According to SIT, adequate interpersonal and small-group skills (SIT principle 4) as well as the motivation to use these skills are a precondition for promotive interactions (SIT principle 3) to occur. Examples of such skills are active listening, communicating accurately and unambiguously, and being able to resolve conflicts productively. We trained children's social skills by gradually increasing the difficulty of the tasks and by specifying beforehand what kind of social skills children should be engaged in. For instance, children had to negotiate which role was best suited for whom at the start of a session. For the empathy exercise they had to listen actively to their fellow team members by repeating in their own words what they had been told. When children did not agree on how to proceed with the collage, they had to provide arguments for their point of view.

Despite this gradual learning process, the first co-design session was not without difficulties. Most children followed their own idiosyncratic interests: they chose roles randomly, they chatted with a friend from another team while they should be listening to a fellow team member and they started cutting out forms without informing fellow team members. However, we noticed a positive evolution towards the second session in, for example, how children dealt with conflicts. In one school, children even started to use the rock-paper-scissors game when they could not reach an agreement (e.g., deciding on the color of the robot's cape). Although the outcome of the game was completely random, the game prevented teams from ending up in Dysfunctional Conflicts.

7.3.6.5 Group processing

The fifth and final mediating principle, group processing (SIT principle 5), was implemented by adding a separate phase at the end of each co-design session. The most challenging part of group processing was to prevent children from blaming each other for things that went wrong, something we had not anticipated initially. In some cases, personal attacks led to further escalations during group processing because the conflicts had not yet been properly resolved. For instance, during the first co-design session, a team got stuck during the problem definition phase and was not sure how to proceed with the collage. Instead of helping his team, one of the boys acted rather silly, coming up with irrelevant ideas. The other team members critiqued his behavior during group processing:

> Girl: "In the beginning, Joe, the whole time, came up with stuff like 'Joe is the best' and… Boy: "Joe is the funniest" Joe: "No, that's not true!" Girl: "It is true!"

To prevent situations like these, we slightly altered the group processing procedure for the remaining sessions. Instead of asking in a straightforward manner what children thought of the cooperation, each team member had to list three actions that had been helpful and one action that could be improved for the whole team. They were not supposed to blame each other, but had to express their concerns in a constructive manner, starting with the words "I wish we…". This intervention led to more constructive dialogues about the group process and how it could be improved, as exemplified by the following quote at the end of the first co-design session:

> Girl: "Uh, I would wish that, for example, we would, if someone is doing a task that is more fatiguing, that we, we could change tasks once, or so."

7.3.7 Conclusions and future work

SIT has proven to be a useful theory to cope with challenging intragroup dynamics in co-design with children. The theory offers a validated framework of five principles that mediate the effectiveness of cooperation: (1) positive interdependence, (2) individual accountability, (3) promotive interaction, (4) appropriate use of social skills and (5) group processing.

We applied these mediating principles to a case study which involved 49 children aged 9 to 10, who designed tangible, digital tools to prevent (cyber-) bullying. SIT proved to be a flexible framework that can be applied in a wide range of contexts.
To some extent, problematic intra-group or co-design dynamics remained in this case study, as described in this paper. SIT principles do not magically cure all challenging group dynamics. However, SIT provides a valuable framework to anticipate on these challenges, and to remediate these challenges into positive forces. For instance, a researcher can point towards children's roles and responsibilities to counter a case of Free Riding. Moreover, since children are encouraged to develop their social skills in SIT inspired co-design, they become increasingly capable of managing differing voices, with little adult facilitation.
Teamwork is a gradual learning process and, in most cases, children need time to adopt a design mindset. In this case study, group processing was essential to improve the collaboration process over time, because children were prompted to reflect on their experiences. Reflection resulted in a posteriori knowledge about teamwork and about how behaviors could be changed to improve collaboration and reach a common goal more efficiently.

The case study described in this paper gave us first insights in the use of SIT in co-design with children. By applying the SIT inspired co-design procedure in other cases and design contexts, our aim is to further develop the procedure and improve its generalizability. Moreover, our hope is that more researchers within the CCI community will report on the use of SIT to cope with challenging intragroup or co-design dynamics.

8. Publications research question RQ1b

Chapter 8 presents one published paper (see section 8.1) and one manuscript under review (see section 8.2). Both publications tackle the second research question on how to analyze co-design outcomes in a transparent and systematic way (cf. RQ1b). These publications and the development of the GLID method were a joint collaboration with Mintlab (KU Leuven – iMinds) colleague Jan Derboven. In his PhD, Derboven relies on multimodal analysis to research how people interpret and appropriate technology. It is in this area that his contribution is to be found. The author of this thesis and Derboven first authored the two publications presented in this chapter. The first paper (see section 8.1) was presented by both authors at the ACM conference for Human-Computer Interaction (CHI) in Seoul (Korea) in 2015. The second paper (see section 8.2) is still under revision for the International Journal of Human-Computer Interaction Studies (IJHCS). The role of the co-authors for both papers was similar to that of the publications in chapter 7: they revised the document and provided well-grounded feedback.

8.1 Multimodal analysis in Participatory Design with children: A primary school case study

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8.1.1 Abstract

We describe a multimodal method for the analysis of co-design outcomes in Participatory Design (PD) with children. The multimodal approach we take allows researchers to treat both verbal (notes, writings) and tangible material outcomes as complementary ways of communicating design ideas. We argue that an integrated approach in which both PD outcomes are compared and contrasted can result in a richer analysis, in which underlying values can be identified more clearly. To illustrate the method, we describe a PD process with primary school children.

Author Keywords

Participatory Design; Values; Multimodality.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

8.1.2 Introduction

8.1.2.1 Participatory Design with children

Participatory Design (PD) is often defined as "a set of theories, practices, and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities" (Schuler and Namioka, 1993). Future users are at the core of the methodology: in PD, these users are considered co-designers of their technology, and of the practices that are reified in that technology. Participatory designers, in turn, are seen as facilitators who try to empower users in making design decisions together (Spinuzzi, 2005). Generative techniques such as co-design are often used in PD. The basic principle behind co-design is to let people make designerly artifacts and tell a story about what they have made. These stories are then used to inform and inspire the design process (Sleeswijk Visser et al, 2005).

Within the area of Child Computer Interaction (CCI), children have participated in the design of technology for over two decades, using a variety of established methods (e.g. Guha et al, 2013; Scaife and Rogers, 1999; Walsh et al, 2010). Nevertheless, it has been acknowledged that it is not easy to involve children as design partners in open-ended, future directed work. Scaife and Rogers (1999) for instance, say that: "On the one hand, the kids come up with many wonderful suggestions [...], on the other hand, many of their ideas are unworkable in computing terms."

This statement is exemplary for a tendency to analyze co-design artifacts solely in computing terms, that is, on a functional or attribute level (e.g. Guha et al, 2013; Walsh et al, 2010). However, the values that are embedded in co-design artifacts are often more interesting than the ideas or functionalities per se (Halloran et al, 2009). Unfortunately, these values (things a person or a group considers important in life (Rokeach, 1973)) are rarely expressed explicitly. Shifting the focus from functionalities and attributes to the underlying motives behind design choices made during co-design can reveal why specific design attributes are important and how they serve children's values. This is in line with recent work by Iversen and colleagues (Iversen et al, 2010) who have attempted to rekindle values in a more authentic approach to PD by focusing on the values that emerge and develop in the course of the design process.
Besides this tendency to focus on concrete design ideas or a set of functionalities when co-designing technology with children, PD researchers often limit themselves to a descriptive analysis of co-design artifacts or rely exclusively on what children say or write about their creations (e.g. Guha et al, 2013; Sleeswijk Visser et al, 2005). However, co-design artifacts should not be regarded as neutral means of accessing children's perspectives. They are always constructed and therefore do not give access to the participants' personal values in a direct and unmediated way. Buckingham (2009) refers to this approach as naive empiricism, arguing that data from creative research cannot be taken at face value: "These data need to be analyzed with special attention for its visual dimensions." Both textual outcomes (i.e., written ideas and what children say about their creation) and tangible outcomes (i.e., the co-design artifact) should be analyzed and interpreted in relation to each other. Nevertheless, the current literature on PD offers little guidance on how to do this in a structured way.

The contribution of this paper lies in offering a method that will enable PD researchers to analyze co-design outcomes by identifying the dominant themes and underlying values, and to integrate both textual and tangible co-design outcomes in a structured analysis. This method is based on multimodal social semiotics (Jewitt, 2013; Kress, 2010). Multimodality provides an interesting perspective on the analysis of co-design outcomes, as it provides an integrated framework for analyzing various ways of communicating, including spoken and written language, but also visual and other modes of communication. As such, it allows for an integration of both textual and tangible co-design outcomes, treating them as different modes used to communicate the same ideas and values.

8.1.2.2 Case study: (Cyber-) bullying in primary school

In this paper, we describe the analysis of a series co-design sessions with children, focusing on the dominant themes and underlying values. We focus on a case study in which 49 primary school children aged 9 to 10 were involved in two co-design sessions. These sessions aimed at designing tangible, digital tools to make primary school children more self-regulatory in combating traditional bullying and cyberbullying. This goal was translated into an understandable design challenge for children: what tools do they need to improve the class atmosphere and prevent bullying? To make it more tangible, we used a fictional story of a class with a negative atmosphere as a starting point for co-design.

8.1.3 Method

8.1.3.1 Participatory Design process

The co-design sessions took place in two schools. In total, 49 children aged 9 to 10 participated and the sessions resulted in 11 co-design artifacts created by an equal number of groups of 4 to 5 children (see Van Mechelen et al., 2014a for an in-depth description of the method used). One researcher was involved in each co-design session facilitating two to three groups of children at the same time without intervening in the creation process. The co-design sessions resulted in various outcomes. For each group, we analyzed:

- a collage of two problematic class situations defined by the children (e.g. children excluding each other from playing games, bullying);
- verbal descriptions on post-its of how a super hero would solve these problems (e.g. Spiderman capturing bad children in a web). From these solutions, the children picked two for further elaboration;
- an artifact designed by the children that embodies the super heroes' solutions chosen in 2;
- transcripts of verbal presentations of the artifact.

8.1.3.2 Multimodal analysis

Multimodality, an interdisciplinary approach based on social semiotics, considers communication and representation to be "more than language, and attends systematically to the social interpretation of a range of forms of making meaning" (Jewitt, 2013). While this type of analysis has been used for researching e.g. games and social networking (Jewitt, 2013), we argue this approach is useful in PD for analyzing both textual and tangible co-design outcomes. Text and tangible artifacts, as different modes, have different affordances: each has specific characteristics that make it suitable for communicating specific information. For instance, while speech is more suitable for narratives, material objects can be easier to communicate moods and emotion. While one specific mode might communicate more information than another, the multimodal approach integrates all modes in the analysis. Through this integration, the analysis becomes a holistic study of the central message that all modes contribute to.

Visual and material objects can, however, be interpreted in different ways, and it can be difficult to make interpretations that are valid in the context of the PD process. Through a comparative analysis between the original ideas and the results, we were able to trace how ideas emerged and evolved throughout the PD process, from initial ideas to results. As such, we were able to interpret the ideas in the co-design artifacts in the light of their origins in the super hero solutions (2) and the description of class situations (1). Tracing this evolution was crucial, as it allowed us to ground the analyses of artifacts (3) and presentations (4) and, as such, add validity to the interpretations. Besides grounding the analyses in the evolution from original ideas to co-design outcomes, we used a hermeneutic approach (Schön, 1984) in order to strengthen the validity: we checked the analysis of the artifact against the verbal transcription, and vice versa. Considering the material artifact and the verbal transcripts as different forms of the same idea, it is the coherence between text and artifact that validates the analysis.

This hermeneutic approach was applied in a close reading (Bardzell, 2011): this is an analytic method originating in the humanities that examines formal and thematic elements in texts and artifacts. It consisted of two main steps. First, two researchers independently identify recurring themes and underlying values through a detailed analysis of the data. This step comprises several activities:

- Tracing the evolution from the children's problem definition (1) and original ideas (2) to the eventual results (3 & 4).
- Performing a low-level analysis of functionality and attributes of co-design artifacts (3) and verbal presentations (4). Special attention is given to elements highlighted in and across modes.
- Performing a high-level analysis of recurring themes by identifying the discourses (i.e., children's view on social reality) that underlie the artifacts and presentations (3 & 4).
- Performing a meta-analysis of values underpinning tangible (3) and textual outcomes (4); these are seldom explicitly expressed.

Afterwards, both researchers collaboratively refine recurring themes and underlying values to arrive at a common understanding of the data. This is an iterative process of going back and forth between the different steps.

8.1.4 Results

In this section, we describe the analysis of both textual and tangible co-design outcomes. We highlight our main findings, illustrating the use of multimodality to analyze the values underpinning these outcomes. While the PD sessions resulted in four outcomes, the collage and post-its served as intermediate stages and have been used to validate the analysis. We focus on the final artifacts and their presentation.

8.1.4.1 From attributes to underlying themes

Friendly authority: Transduction from artifact to presentation

Groups 3, 7 and 10 created artifacts with human-shaped figures, and groups 4, 5, 6 and 8 all created robots. These groups associated all kinds of functionality with their figures, ranging from ringing a bell when things threaten to go wrong (group 3), to a DJ robot for a class party (group 4 – figure 1, right). Beyond these specific functionalities, these anthropomorphic figures all represented some type of authority, influencing the children's behavior. Generally, the robots did not look sterile, but had some kind of personality that was implicitly described in the participants' presentations (e.g. "he tells very good jokes"), and more explicitly visualized in the artifacts. While all robots had some kind of regulatory function, most robots looked funny or friendly in some way. For instance, group 3 made a kind-looking figure with a big red heart. The DJ robot by group 4 created a fun atmosphere, and would "eat all bad ideas".

Only group 6 created a rather severe-looking robot (figure 38, left), with a clearly regulating, authoritative function (visualized in a traffic light on his body). However, while the severe component was present in the visual appearance of the robot and mentioned in the children's presentation, it was not present in the further material elaboration. Whereas the robot did contain games to reward well-behaved children, the punishing aspect was not elaborated: the artifact only highlighted (gave special weight to (Kress, 2010)) the rewards. This observation suggests that disciplinary punishment was not central to the children's understanding of a tool to prevent and combat (cyber-) bullying in a class context. While many artifacts took the shape of an authoritative figure, the transduction (i.e., the translation from one mode to another (Kress, 2010)). from the textual to the tangible added an important nuance. The objects showed that the authority is always friendly, focused on rewarding rather than on punishment.

Good and bad children: Agency and group processes

Although the children were asked to invent objects that would improve the classroom atmosphere, none of the PD groups made representations of the class, the teacher, or other actors in their artifacts. Therefore, it was important to analyze the children's presentations to determine whether or not the artifacts themselves had agency, and to determine their orientation (Kress, 2010): whether the artifacts are oriented at specific bullies, victims, or the class group as a whole. In analyzing artifact orientation, three dominant artifact categories emerged. The first category consisted of artifacts with agency that concentrated on the class group as a whole (3 out of 11 artifacts). Children explained their function without referring

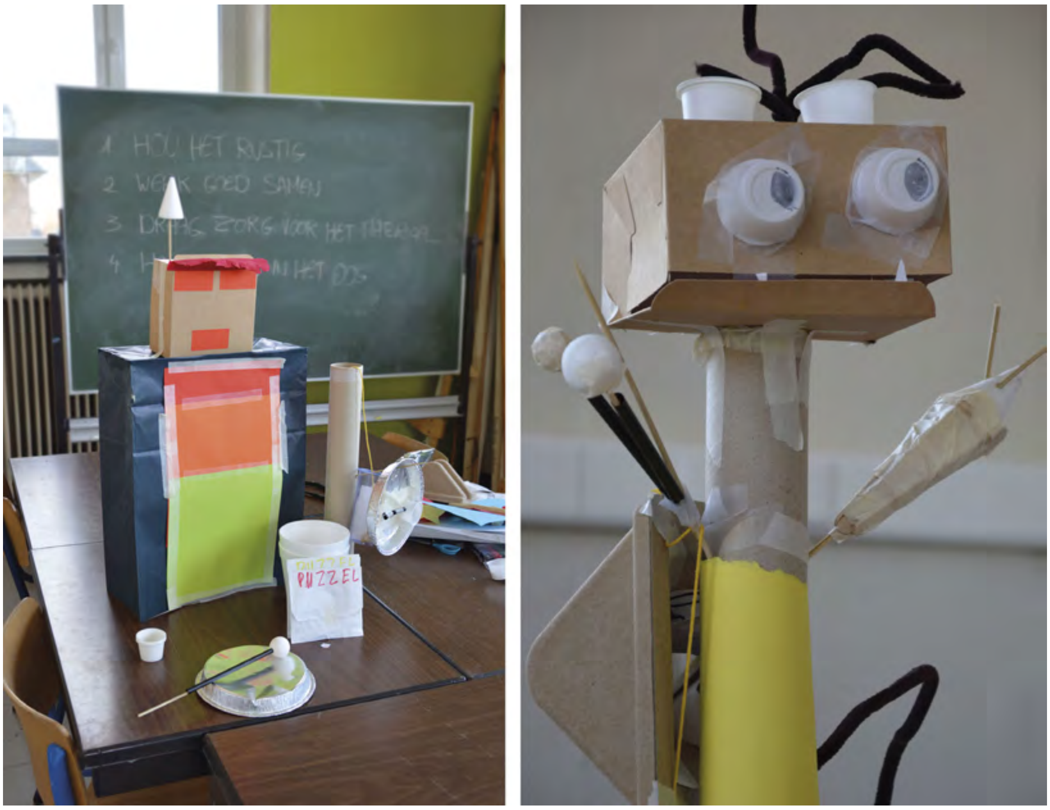

Figure 38: Goofy DJ robot (right) vs. severe-looking robot (left), groups 4 and 6

to good or bad children. For example, the DJ robot (figure 38, right) improved the class atmosphere by telling jokes and by "eating all bad ideas", while another robot gave children a magic potion to make them friendly.

The remaining 8 artifacts were clearly targeted at either bullies or bad children and victims or good children. We distinguish two further categories. Artifacts in the second category (5 artifacts out of 11) distinguish between bad and good but were not targeted at punishing bad children. Two artifacts with agency focused on mediation instead of punishment, and three tools without agency made children forget their bad behavior, or resolved tensions through play. A third category (3 artifacts without agency) mentioned both rewarding and punishment, but focused on the rewards (e.g. allowing good children to play games). In these artifacts, punishment was not elaborated, or only minimally.

The analysis above shows that not only the artifact itself and its attributes are important, but also the way it mediates between other actors on a more abstract level. On the one hand, the first two categories (8 out of 11 artifacts) either made no reference to bullies and victims, or concentrated on resolving tensions between bullies and victims while also avoiding punishment. On the other hand, the remaining artifacts (3 out of 11) more clearly encouraged good children and punished bad children. In these artifacts, however, the punishing was understated: the focus was on rewarding.

8. 1. 4. 2 From themes to values

From the themes emerging from the analysis above, information on the children's values can be deduced. The artifacts in the first two categories, focusing on the class atmosphere as a whole or on mediation and play, fit in a no-blame discourse. In this discourse, it is important not to single out the bad children to punish them, but to take a preventive attitude by defusing tensions in the classroom. On the other hand, the artifacts in the third category did use a discourse focused on rewards and punishment; still, these artifacts highlighted the positive aspect of rewarding.

In general, however, both the no-blame artifacts and the artifacts differentiating between good and bad children pointed towards an emphasis on values of soft authority and positivity in various ways. The no-blame artifacts did this by focusing on the class group as a whole or used strategies such as mediation or play. The artifacts with agency had a friendly type of authority, rather than a strict, punishing one. Even the artifacts centered on good and bad behavior had a heavy focus on rewarding good behavior, understating the punishment aspect. Going beyond specific functionalities, these emerging values of soft authority and positivity provide designers with a well-grounded starting point for designing tangible, digital anti-bullying tools.

8.1.5 Analyzing Participatory Design values

When analyzing the outcomes of co-design sessions, it is essential to pay attention to both textual and tangible outcomes. As textual and tangible co-design outcomes are different ways of communicating the same ideas, it is important to analyze which aspects have been transduced (Kress, 2010) from the textual to the tangible and vice versa, and which have not. This way, it becomes clear how different modes complement each other in communicating a message.

The multimodal analysis allowed us to create rich analyses of both textual and tangible outcomes. The analysis teased out dominant themes and values, going beyond the surface of functionalities and attributes. For instance, the appearance of the anthropomorphic figures added important nuances to their interpretation. The analysis did not focus only on the functionalities of the figures, but on their personality, implicitly present in the verbal presentations of the artifacts, and more explicitly in their tangible form. As these personalities can be linked to underlying values concerning the prevention and reconciliation of conflicts, the artifact analysis was important to arrive at a nuanced interpretation.

While the current PD literature offers little guidance on the analysis of material outcomes, multimodality offers a structured framework to analyze both textual and material outcomes, and the transduction between the two. The case study above focuses on tangible and verbal modes, but multimodality can be useful in the analysis of other modes as well (Jewitt, 2013). As such, we believe that the approach is applicable in various PD situations, with different design challenges and materials. Especially analytic concepts (e.g. highlighting, agency, orientation) are instrumental in analyzing discourse and values underpinning co-design outcomes.

In the case study presented above, multimodality provided a framework to identify the values underlying the children's design choices within and across co-design teams. Using the framework, designers can go beyond the surface level of cherry-picking participants' ideas. In future work, we will further tailor the multimodal framework to the analysis of co-design outcomes, and apply it to various case studies.

8.2 The GLID method: Moving from design features to underlying values in co-design

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8.2.1 Abstract

In this paper, we present the GLID method to integrate verbal, material and other co-design outcomes in a structured and coherent analysis. GLID aims to increase internal rigor and transparency in Participatory Design practices and wants to go beyond the surface level of ideas, by identifying participants' values embedded in co-design outcomes. We discuss GLID's theoretical groundings in multimodality and a values-led approach to Participatory Design, and present a case study with primary school children. This case study demonstrates how the different stages of the GLID method can be applied in practice. Based on the case study, we reflect on how GLID contributes to a holistic, situated and more empathic understanding in co-design practices.

Keywords

Participatory Design, co-design, values, multimodal analysis, means-end theory, design methods

8.2.2 Introduction

Participatory Design (PD) is often described as a set of theories, practices and studies related to the design of technology, aiming to give those that will ultimately be impacted by the technology a voice in its design (Muller, 2002; Schuler and Namioka, 1993). Although PD lacks a strict definition or set of rules, PD aims at establishing partnerships with future users and other relevant stakeholders. Important principles to establish these partnerships are the sharing of decision-making power and establishing a process of mutual learning (Bratteteig et al., 2013). To this end, different techniques that focus on telling, making, and enacting (Brandt et al., 2013) are used to assist participants in analyzing their experiences and giving meaning to them (Veale, 2005). Rather than extracting knowledge from participants, PD aims to co-construct knowledge and shed light on how people engage in world making in their current and future lives. Moreover, in PD, future users are typically involved in the creation of the technological artifact and the practices surrounding it (Bratteteig et al., 2013).

In this article, we focus on one specific way to engage in making activities with future users. Specifically, we focus on the use of co-design with children. Co-design techniques are used at the early, fuzzy stages of design to collectively explore and express future ways of living (Sanders and Stappers, 2008). The basic principle is to guide participants in small steps to construct designerly artifacts with 2D and 3D visual components that are often ambiguous in nature. Afterwards, the participants explain what they have made and why. These stories are then analyzed to inform and inspire the design process (Sleeswijk Visser et al., 2005).

Under the influence of PD, the role of children in design processes has changed tremendously (Read and Markopoulos, 2013). Whereas children were initially involved passively as technology users, their role was gradually broadened to that of active participants using a variety of co-design techniques (e.g., Dindler et al., 2005; Druin, 1999; Gielen, 2008; Horton et al., 2012; Moser, 2012; van Doorn et al., 2013). Nevertheless, it has been acknowledged that it is not easy to involve children as design partners in open-ended, future directed work (Scaife and Rogers, 1999).

The particular challenge that will be addressed in this paper is how to analyze children's contributions in co-design activities. Whereas some authors stick to a descriptive analysis (descriptive perspective), others take a more interpretative stance by looking at deeper levels of knowledge or values embedded in co-design outcomes (knowledge perspective). Within the latter perspective, two shortcomings can be identified: (1) a unilateral focus on the verbal explanation while neglecting the material dimensions of co-design artifacts, and (2) a lack of transparency when interpreting children's contributions. To address these shortcomings, the GLID method is presented, aiming to integrate the material dimensions of co-design artifacts and their verbal explanation in a structured analysis. The method goes beyond a descriptive analysis of children's ideas and aims to identify the values embedded in co-design outcomes.

This paper is structured as follows. In Section 2, we present the theoretical background of our work in co-design and multimodality. Afterwards, we present the GLID method in detail in section 3. To illustrate this method, we present a case study with primary school children in sections 4 and 5. Finally, we conclude the paper with a discussion of how GLID contributes to PD research.

8.2.3 Related work

8.2.3.1 Interpreting co-design outcomes

Descriptive versus knowledge perspective

The challenge of interpreting children's contributions resulting from co-design activities traces back to Scaife and colleagues' groundbreaking work in the late 90s (Scaife et al., 1997). They were among the first to give children a more active role in technology design, but, at the same time, acknowledged that this was not without difficulties. Compared to adults, children use different conceptual frameworks and terminology, which makes it difficult to understand the exact meaning of what a child is trying to say. In addition, although children come up with many wonderful suggestions, their ideas are often unworkable in computing terms or may conflict with educational goals (Scaife and Rogers, 1999). This problem of how to deal with children's contributions resulting from co-design activities has been a topic of much debate since then in the Child Computer Interaction (CCI) community.

Broadly speaking, a distinction can be made between researchers looking for inspiration in the form of workable design ideas (i.e., taking a descriptive perspective) (e.g., Druin, 1999; Guha et al., 2013; Knudtzon et al., 2003; Mazzone et al., 2008; Read et al., 2014), and researchers that take a more interpretative stance by looking beyond the surface level of children's ideas to deduce knowledge embedded in co-design outcomes (i.e., taking a knowledge perspective) (Dindler et al., 2010; Frauenberger et al., 2012; Gielen, 2008, 2007; van Doorn et al., 2013). If there is not yet a well-defined design problem, approaches that fall under the knowledge perspective may be more appropriate as they provide researchers with profound insights in what drives and motivates children. In later design stages, the descriptive perspective may be preferable as the focus will have shifted from problem to solution finding. At this point, researchers may be more interested in quickly developing one or more prototypes based on a descriptive analysis of children's ideas, focusing on functional elements (e.g. product features) and aesthetic characteristics. In this paper, we focus on the knowledge perspective, presenting a method to help researchers at the early, fuzzy stages of design in their analysis of children's contributions.

Within the knowledge perspective, different types of knowledge can be revealed relying on co-design techniques. Sanders (2002, 1992; Sanders and Simons, 2009), for instance, argues that the act of making in co-design activities enables participants to reflect upon their experiences and express deeper levels of knowledge that would not have surfaced without such concrete materials. With deeper levels of knowledge she refers to people's tacit and latent needs. These needs cannot readily be expressed in words, as they are typically future needs that are difficult to identify in the present (Polanyi, 1983 as cited in Sanders, 1999). To unravel these deeper levels of knowledge, Sanders (1999) focuses on the story that comes along with the co-designed artifact: "Every artifact tells a story and so we typically ask the creator of the artifact to tell us that story." A common approach to analyze these stories is to center on identifying the themes that occur most frequently in transcripts of participants' verbal explanations (Sanders and William, 2001). These recurring themes are believed to reflect participants' tacit and latent needs.

Within the knowledge perspective, other researchers have focused on using co-design techniques to elicit values, a particular kind of knowledge (e.g., Halloran et al., 2009; Iversen et al., 2010). Our method fits within this subcategory and aims to deduce children's values embedded in co-design outcomes. The concept of value has been used in psychology to explain the motivational basis of attitudes and behavior. Rokeach (1973), for instance, defines a value as "an enduring prescriptive or proscriptive belief that a specific end state of existence or specific mode of conduct is preferred to an opposite or converse end state or mode of conduct". Although Sanders (2000, 1992) does not explicitly use the term values, her conception of tacit and latent needs does not seem that different. Just as values, tacit and latent needs are relatively stable and critical motivators for participants' attitudes and behavior (Rokeach, 1973; Schwartz, 1992).

Focusing on values (e.g. transparency, benevolence, autonomy and privacy) fits within a broader trend in Human-Computer Interaction (HCI) to address the design of technology by focusing on what endures beyond interaction, that is, the outcomes and lasting impacts, and not by the ease-of-use and contextual fit alone. This has led to a proliferation of design approaches that have concerned themselves with values (e.g., Cockton, 2004; Fleischmann, 2014; Friedman et al., 2006; Iversen and Leong, 2012; Sengers et al., 2005). What most of these approaches have in common is that they hold an interactional position on the relation between values and technology: they see values as neither inscribed into technology nor as simply transmitted by social forces, it works both ways (see also, for instance, Bijker et al., 1985). Since technology cannot be considered to be value-neutral, the underlying idea is that the values of those impacted by technology should be taken into account throughout the design process.

PD holds a similar position on the relation between values and technology and has been a highly values-led design approach from its very beginnings. However, compared to other values-led design approaches (e.g., Cockton, 2004; Fleischmann, 2014; Friedman et al., 2006), PD differs in that values are not seen as something that is 'applicable' to design after being identified first. Rather, the values at stake and the artifacts being designed mutually influence each other as the design process unfolds. This situated view on values implies that the same values can be appropriate in one context but problematic in another and that there is no single interpretation of values that serves all situations (JafariNaimi et al., 2015). Moreover, knowledge generation in PD is seen as a dialogic process that is strongly situated and mediated by participants' personal values (Frauenberger et al., 2015). The co-design process is regarded as a negotiation of values that the participants bring to the table or which emerge from the collaborative experience (Iversen et al., 2012, 2010; Iversen and Leong, 2012).

With co-design techniques, values can be elicited both on an individual and collective level. On an individual level, the act of making helps to raise awareness about one's own values and value tradeoffs, because reflection about the design challenge is not detached from action, i.e. making a solution for a specific context. On a collective level, these personal values are simultaneously negotiated with other participants, either implicitly or explicitly. This may in turn influence participants' personal value systems and reframe the design problem. For example, in a series of co-design activities about how to balance the risks and opportunities of social media, children initially valued free exploration and social recognition of their peers, whereas parents emphasized online security. Throughout the activities, these emerging values evolved, and, eventually, the team developed a concept for a parental mediation application. Rather than to restrict internet access, the application aims to increase children's social media literacy through peer learning and open communication with their parents (Donoso et al., 2014). Iversen and colleagues (2010) refer to this process as the emergence, development and grounding of values into one or more artifacts and, ideally, in the participants' future practice. This joint sensemaking or collective reflection in action is at the heart of PD (Ehn, 1993). A core task for design researchers is to mediate this process and facilitate dialogue between participants. Since not all values emerge by explicit means, careful observation and interpretation of the co-design artifacts are required (Iversen et al., 2010).

Knowledge discovery and analysis

Embedded knowledge (e.g. tacit and latent needs, values) is often deduced by focusing on the verbal component of a co-design outcome as the main unit of analysis, whereas the material dimensions are somewhat neglected (Sanders, 1999; Sleeswijk Visser et al., 2005; Stappers and Sanders, 2003). This focus on participants' verbal explanation assumes that co-design artifacts are regarded as a transparent means to access embedded knowledge. Piper and Frankham (2007) have referred to this approach as an 'uncritical celebration of representation', emphasizing that verbal explanations should be analyzed in relation to the visual materials and the role of the researcher in producing and presenting these materials (Piper and Frankham, 2007). Similarly, Buckingham (2009) has used the term 'naive empiricism', arguing that data from creative research cannot be taken at face value: "these data need to be analyzed with special attention for its visual dimensions". He continues that we need to be wary of the idea that any particular method necessarily allows participants a direct or transparent means of expressing themselves or having their voices heard. Instead of falling back on verbal accounts or a descriptive analysis, methods are needed that can deal specifically with the visual dimensions of such material (Buckingham, 2009). Both 'verbal outcomes' (i.e., what participants say or write about their creation) and 'material outcomes' (i.e., the co-design artifact, constructed in 3D) should be analyzed and interpreted in relation to each other (Derboven et al., 2015).

Like Piper and Frankham, and Buckingham, we endorse the view that material co-design artifacts and their verbal explanations are always 'constructed' and therefore do not give access to deeper levels of knowledge (e.g., Sanders, 2002, 1992; Sanders and Simons, 2009) or values (e.g., Halloran et al., 2009; Iversen et al., 2010) in a direct and unmediated way.

However, the current literature on PD offers little guidance on how to analyze and interpret verbal and material outcomes in relation to each other, and in a structured and transparent way. To fill this gap, Brandt and colleagues have already called for more research on how to analyze data generated by making, telling and enacting activities, including generative techniques such as co-design (Brandt et al., 2013).
In addition, Frauenberger and colleagues have argued for more internal rigor and accountability in PD practices, be it not in a positivistic or reductionist sense. In line with its roots in social constructivism and phenomenology, more holistic and interpretative approaches are needed to analyze participants' contributions in PD, aiming for systematic and critical reflection (Frauenberger et al., 2015; Lee, 2014). This is especially true when involving children as design partners. When it comes to abstract concepts such as values, children may have a difficult time verbalizing their thoughts (Piaget, 1970). However, since values are critical motivators of attitudes and behavior (Rokeach, 1973; Schwartz, 1992), the way in which children approach a design challenge tells us something about their values, albeit implicitly. Deducing these values requires a process of interpretation and rigorous attention for both the material characteristics of co-designed artifacts and their verbal explanation. This paper offers a method to demystify this process of interpretation and, ultimately, arrive at children's values embedded in co-design outcomes.

8. 2. 3. 2 Multimodal semiotics

Analyzing communicative modes and metafunctions

Multimodal semiotics (also known as 'multimodality', see e.g. (Jewitt, 2013, 2010) is a semiotic approach that finds its origins in the functional linguistics of (Halliday, 1978), and the social semiotics of e.g. Hodge and Kress, (1988). As a semiotic approach, multimodality concentrates on how communication is structured and presented. Specifically, multimodality has proven its usefulness in the analysis of digital technologies (Jewitt, 2013; Zhao et al., 2014), and even in the analysis of a specific PD case with children with Autistic Spectrum Disorder (Malinverni et al., 2016). The GLID method presented below builds on this work, providing a structured method to integrate the material dimensions of co-design artifacts and their verbal explanation in a structured analysis. The method goes beyond a descriptive analysis of children's ideas and aims to identify the values embedded in co-design outcomes. In our approach, two basic assumptions of multimodality are relevant for the analysis of co-design outcomes: the assumption that all communication consists of various communicative 'modes' (e.g., written, verbal, visual), and the assumption that all communication can be analyzed in terms of three 'metafunctions'.

The first assumption is that communication is more than only the use of language: communication always includes several 'modes' that contribute to the meaning of a message (Kress, 2010). Modes, in this framework, can be seen as 'channels' of representation or communication (such as writing, image, sound) that collaborate in communicating messages (Jewitt, 2013). This analysis of different modes emphasizes that each mode has different affordances: specific characteristics that make them suitable for communicating specific information (Jewitt, 2010). For example, while text is more suitable for narratives, images can be easier to communicate moods and emotions. Similarly, in co-design outcomes, various modes of communication are used, such as verbal communication (spoken or written), visual communication, body language, etc. As all of these specific modes communicate different information, multimodality is a useful approach that allows for an integration of these modes in one holistic study. For the analysis of co-design outcomes, we use a division in general modes of communication, such as 'verbal' (the participants' explanations, either written or oral) and 'material' (artifacts, including their visual and tangible features) modes.

The second assumption relies on a distinction between the different functions that every communication fulfills. In line with its social semiotic origins, multimodality identifies three basic functions of communication, called 'metafunctions'. These 'metafunctions' analyze 1) what is presented (which reality is being represented?), 2) who is involved (how are social relationships constructed between actors in this reality), and 3) how is the communication structured (how is the message structured as a coherent entity that makes sense?).

The multimodal analysis into communicative modes and metafunctions aims to offer insights into how communication is structured, and how it presents a specific view on reality. Such "socially constructed knowledges of some aspect of reality" (Van Leeuwen, 2005: 94) are called 'discourse', in multimodal semiotic terminology. In every communication, reality is represented in a selective, socially constructed way. Specific aspects of reality are included and arranged in a particular way, and as such, each selection indirectly represents a set of socially shared values (Barker and Galasinski, 2001). Therefore, the multimodal analysis will play a central role in the GLID method described below, as it is instrumental in making explicit how a specific view on reality is constructed in co-design outcomes.

Multimodal semiotics, discourse and values

In the GLID method, we will use multimodal semiotics to analyze the discourse embedded in the co-design outcomes. This analysis of discourse will lead us to an insight into the values that underpin the co-design participants' outcomes. In order to clarify our use of a multimodal, semiotic approach for the analysis of values in PD, we will complement it with a brief discussion of means-end theory. According to means-end theory, people choose a product because it contains certain attributes (the means) that are instrumental to achieve desired consequences or benefits, which, in turn, fulfill certain values (the ends) (Gutman, 1982; Reynolds and Gutman, 1988). This theory has been used in HCI to analyze how technology relates to user values (e.g., Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010), and also stresses social constructedness in its discussion of product use (Reynolds and Gutman, 1988).

At first sight, there are obvious differences in approach, terminology, and intellectual roots between multimodality and means-end theory. While means-end theory describes how surface features are related to underlying values, multimodality describes how surface features combine into specific discourses (e.g., Van Leeuwen, 2005). Values and discourse are not

MEANS-END THEORY	MULTIMODAL SEMIOTICS
Product features (cf. attributes)	Product features
↓	↓
Direct and indirect consequences or benefits	Communicative modes and metafunctions
↓	↓
Values	Discourse

Figure 39: Means-end theory and multimodal semiotics 'drill down' to respectively values and discourse in a similar way.

interchangeable in PD, but we do argue that most values are embedded implicitly in the way participants represent reality in a selective way. Through the analysis of discourse (i.e., analyzing the situations described in the co-design outcomes, and the way they change the current status quo), it becomes possible to access the social value systems embedded in it. In means-end theory, the analysis of product features (also termed attributes) and their consequences progressively 'drills down' to an analysis of underlying values. A similar procedure can also be found in multimodality, where the analysis of different modes of communication and metafunctions leads to an analysis of discourse. As such, both methods can be used to 'drill down' to underlying values or discourse mediated through the intermediate steps of either consequences or metafunctions.

Inspired by applications of means-end theory in HCI (e.g., Vanden Abeele et al., 2011; Zaman and Vanden Abeele, 2010), progressively 'drilling down' to an analysis of underlying values, we argue that multimodality can be used in a similar way to analyze co-design outcomes (see Figure 39). The combination of the analysis into communicative modes and metafunctions (see 2.2.1) makes multimodality well-suited for an integrated analysis of verbal, material and other co-design outcomes that reaches out to underlying discourse and, ultimately, value orientations. As such, multimodality can enable design researchers to uncover the discourse and values underpinning co-design outcomes. In the next section, we will describe this 'drilling down' to underlying values in detail, as we describe the various analytic stages of the GLID method.

8.2.4 Description of The GLID method

Inspired by a values-led approach to PD and multimodal semiotics and, the multimodal GLID method consists of four broad stages: Grounding the analysis, Listing design features, Interpreting orientation and organization, and Distilling discourse and values (Figure 40).

8. 2. 4. 1 Grounding the analysis

What

Inventorying the set of initial ideas that came up during the sessions. Tracing the evolution from initial ideas to final outcomes, and situating the final outcomes against the background of their origins.

Why

Situating co-design outcomes in its origins can clarify why certain (design) decisions were made. Tracing the origins can help to contextualize the eventual outcome, especially when that outcome proves to be ambiguous in some respect.

Apart from grounding the analysis, it can be enlightening to see how the initial ideas have been transformed during the co-design process and how they have made it into the final outcomes. Tracing the evolution of the selected ideas can already give a first insight into the type of outcome that was targeted (Van Mechelen and Derboven, 2014).

How – Relevant questions

How did the co-design outcomes grow and transform into their final form? Which early, constituent ideas can be traced? Which ideas did not make it to the final outcomes?

8. 2. 4. 2 Listing design features

What

Listing design features in detail. Differentiating between different modes of communication (visual, material, etc.), and tracing which features are communicated in which modes.

Why

Listing design features provides a basic description that can be used for further, more thorough analysis. This listing of features can also provide a first insight into which features are highlighted as the most salient features, and which features have been given less attention.

This stage is based on the first of the three metafunctions in multimodality: the presentational

metafunction (the terminology is based on Lemke's (2002) view on metafunctions). The presentational metafunction is related to the concrete, functional layer of designed artifacts. It is a description of the 'state-of-affairs', detailing what aspect of reality is presented in the co-design outcome. It describes what is represented, and what activities potential users or stakeholders engage in. As such, both functional (actions that can be performed) and non-functional (visual, aesthetic) aspects of the co-design outcomes are described. In means-end terminology, this is a detailed overview of the directly perceivable attributes (material, visible product features) and their functional consequences (immediate tangible benefits: the purposes they serve and the interactions they allow).
Furthermore, combined with the first step (Grounding the Analysis), various design features can already be traced back to their origins. This additional background on the design features provides the basis for the analysis described below.

How – Relevant questions

What do the co-design outcomes consist of? Which features do they have? Which features stand out? Which actors and objects participate in the reality presented through the co-design outcomes? Which modes are present in the co-design outcomes? In which mode are the features communicated? What are their functions?

8. 2. 4. 3 Interpreting orientation and organization

What

In this stage, the analysis focuses on how the co-design outcomes are presented as a coherent whole, projecting a reality with specific social relationships between various actors.

Why

This step is based on the two last metafunctions identified by multimodality: the orientational and organizational metafunctions.

Orientational

This analysis focuses on contextual social relations, and therefore specifies 'attitudes' towards the state-of-affairs in the co-design outcome mentioned above. Analyzing the features' orientation determines how actors, in the reality projected by the co-design outcome, are (implicitly or explicitly) involved in the interaction with the outcome. As such, the orientational metafunction focuses on social consequences. It evaluates and positions the situation (desirable or not, necessary or obligatory, etc.) and evaluates the relationships among participants and objects (in terms of power relations, influence, etc.). The orientational layer is especially important for PD, as it specifies how specific social situations are evaluated, offering insight in the way in which specific values are embedded. In other words, this analysis focuses on shared meanings, attitudes and relations that hint towards specific values (Lemke, 2002).

Linking multimodality with means-end theory, the orientational meaning relates to psycho-social benefits. It is an analysis of how the co-design outcome intervenes in a specific situation, and which psychological or social consequences are linked to it. These consequences embody the meaningful, alternative futures envisioned by the PD participants.

Organizational

Analyzing the features organizationally shows how the co-design outcome as a whole is constructed as an artifact, a story or in another discursive form. Here, the focus is on how the initial co-design idea or challenge was 'translated' into a coherent outcome, integrating or contrasting different features and value orientations into a whole.

The interaction between the various modalities is important. As different modes can communicate different types of information (see also 2.2.1), it is important to analyze how different modes work together in order to communicate a message (i.e., the cohesion between modes). Do different modes confirm and reinforce each other, or contradict each other? Are the same features present across modes presented in a similar way ('transduced' (Kress, 2010) from one mode to another), or do different modes emphasize different features?

How – Relevant questions

Orientational

Which actors are involved in the use of the artifact, directly and indirectly? Which stakeholders are mentioned by the co-design team and which are not? What are the relationships among these actors, and how does the artifact mediate these relationships? What are the psycho-social benefits for the different actors?

Organizational
How was the initial co-design challenge or idea brought together into one co-design outcome? How does the outcome constitute a meaningful whole (application, tool, etc.)? How are specific messages confirmed and reinforced (highlighted) across modes? Does the analysis lead to contradictory interpretations across modes?

8. 2. 4. 4 Distilling discourse and values

What

Distilling the discourse based on the previous analytic stages. In this stage, the focus is which specific discourse is used to envision future practices and technologies, and which values this discourse represent.

Why

In this stage, the previous stages culminate in a meta-analysis of how the future practices and situations evoked in the co-design outcomes are evaluated in terms of the PD participants' underlying and negotiated values. Guided by the trajectory from initial idea to eventual co-design outcome (Grounding stage), this stage sums up how the co-design outcome represents a specific aspect of reality (Listing stage), combining various modes of communication in a coherent way (Interpreting stage: organization). Together, these elements form the specific discourse (a 'socially constructed knowledge of some aspect of reality' (Van Leeuwen, 2005)) presented in the co-design outcome. The outcome therefore represents a specific selection and configuration of that reality: e.g., social relationships between actors are always constructed in a particular way (Interpreting stage: orientation).
As such, the meta-analysis builds on the previous analytic stages to show which specific discourse is used to envision future practices and technologies, and which values this discourse represent. This discourse is essentially a coherent synthesis of the analysis from the second and third stage. However, in this phase, the goal is to transcend the details of the specific situation described in the co-design outcome (e.g., specific functionalities - see 3.2), and move towards the values that underpin and motivate these specific, contextual details. From this discourse, specific value orientations can be deduced.

How – Relevant Questions

Which aspects of reality are included and excluded in the co-design outcomes? How are these aspects of reality evaluated? How does the artifact represent and influence this reality? With what purpose? How is it legitimated? Which set of values is communicated through this representation of reality?

Figure 40: The four broad stages of the GLID method for analyzing co-design outcomes.

8. 2. 4. 5 Summary

In summary, relying on GLID, design researchers are guided through a stepwise procedure for analyzing co-design outcomes. Different modes of communication are integrated in a coherent analysis in order to 'drill down' to children's values (see figure 40). In the stages outlined above, stages 3 and 4 are the most interpretative ones. While literature on co-design already has a tradition of analyzing verbal outcomes, this is not the case for the analysis of visual, or material outcomes. This raises the question of the validity of the interpretations: are they constructed in a systematic and transparent way? This can be addressed in several ways. First, consistency among different modes can be analyzed: considering the different modes as different aspects of the same idea. While contradictions between modes are possible, in general it is the cohesion across modes that validates the analysis. The separate interpretations of different modes from stage 2 (listing design features) are brought together in one interpretation in stage 3 (interpreting orientation and organization). This unified analysis allows for an analysis of similarities and differences between various modes. For instance, the same feature can be present across modes in a similar way ('transduced' (Kress, 2010) from one mode to another), different modes can emphasize different features, etc.

As a second validation, the interpretations of design features can be grounded in their origins. Checking the interpretations in this stage for consistency with the outcomes' origins traced in stage 1 provide additional validity. If the interpretations prove inconsistent with the origins, the co-design process itself should be examined for specific shifts in meaning and interpretation. If these shifts can be traced, the inconsistencies between the origins and the outcomes can be brought back to the co-design process itself. In this case, it is necessary to analyze why and how these shifts in meaning and interpretation have occurred. However, if no shift in meaning can be traced, the interpretations of the outcomes can be revised: in this sense, the interpretive process is iterative.

Finally, as the GLID method has been developed to analyze underlying values in co-design outcomes, it is important that researchers are aware of the values they bring to the PD process themselves. Methods to uncover these values have already been introduced in the PD literature (Frauenberger et al., 2015; Read et al., 2013; Van Mechelen et al., 2014b). Hence we advise to make this reflexivity explicit, perhaps as an extra step at the start of the GLID method, and certainly before step 3 and 4, when listing psycho-social benefits and analyzing the values embedded in the co-design outcomes. It is important to note to what extent the participants mimicked the researcher's values, or transcended or modified them.

8. 2. 5 Case study procedure

To illustrate the GLID method, we present a case study in which 49 children aged 9 to 10 were involved in a series of co-design sessions in two schools in Flanders, Belgium. The sessions were part of a project aimed at the design of tangible, digital tools to make class groups more self-regulatory in the prevention of both traditional bullying and cyberbullying. This goal was translated into an understandable design challenge for children: what tools would improve the class atmosphere and prevent bullying? To make it more tangible, we used a fictional story of a class with a negative atmosphere as a starting point for co-design. In the story, that was read out loud when we first met the children, our own values with regard to the problem of bullying were embedded: we aspired a proactive approach that would increase children's self-regulative behavior, with the ultimate goal to create a safe environment for children. Although we started from these preliminary value orientations (prevention, increasing self-regulation) and from a broad view on what was to be designed (tangible, digital tools), these preliminary ideas were open to change. During the co-design sessions, we allowed the children's work to challenge our ideas and broaden our perspective.

Over a period of one month, two co-design sessions were organized in two primary schools (150 minutes each) preceded by a general introduction (50 minutes), resulting in three visits per school. Two of the authors were involved in the co-design sessions, each facilitating two to three teams at the same time, without intervening in the creation process. Below we will briefly describe the different sessions. For a detailed description of the co-design procedure and the prompts used in this particular case, we refer to Van Mechelen and colleagues (Van Mechelen et al., 2015, 2014a) (2015, 2014a).

8. 2. 5. 1 Introduction and sensitizing

When we met the children for the first time in their classroom, we explained the design challenge and we introduced a sensitizing package (Sleeswijk Visser et al., 2005) with four individual assignments. The goal of these assignments was to trigger children's reflection in a playful and creative way, and to prepare them for the co-design sessions approximately two weeks later. One of the outcomes, that is, an assignment in which they had to draw a class with a bad atmosphere, was also used to construct a fictional story to be used as a starting point for co-design.

8. 2. 5. 2 First co-design session

The aim of the first co-design session was to create cohesive teams and, for each team, to define two problems based on the story and the design challenge. After introducing the story, the class group was divided into gender-mixed subgroups of five children. Each team member had a special responsibility within the team (the material master, the inspiration general, the time keeper and the silence captain). These roles were visualized on badges and were divided amongst the children of the team. Next, the teams were engaged in introductory design activities (e.g. group name and logo design) to get used to working in a team and to increase social cohesion. Afterwards, the teams visualized the on a big sheet of paper (collage) and defined two design problems based on their interpretation of the story. The story was printed on cards, one for each team, as a visual reminder. When the teams were finished, they briefly presented and explained their collages to the other groups. The session ended with a short discussion about the group process and how it could be improved during the next session.

8. 2. 5. 3 Second co-design session

The aim of the second co-design session was to design and prototype the actual tools. We first introduced the children to the concept of brainstorming, after which each team thought of different ideas of how a superman would solve the problems defined during the first session. Each idea was written on a separate sticky note and put in the middle of the table to inspire the other team members. Next, the teams grouped similar ideas together and selected two ideas for further elaboration. To build their three-dimensional prototype, the teams received a bag full of materials (e.g. scissors, cardboard, glue, ropes, aluminum dishes, etc.). Once finished, each team verbally presented their invention (see, for example, figures 41, 42 and 43), while the other teams functioned as a jury, providing constructive feedback. These presentations were recorded on video. The session ended with a short group discussion about how we would take their designs forward in the next stages of our research.

The co-design sessions resulted in various outcomes. For each group, we analyzed:

- a collage of two problematic class situations defined by the children during the first co-design session (e.g. children excluding each other from playing games);
- verbal descriptions on post-its of how a superhero would solve these problems (e.g. Spiderman capturing bad children in his web). From these solutions, the teams picked two for further elaboration;
- an artifact designed by the children that embodies the solution chosen in 2;
- transcripts of verbal presentations of the artifact.

8.2.6 Results

8.2.6.1 Eleven co-design outcomes, three examples

Within the scope of this paper, it is not possible to offer detailed analyses of all eleven artifacts and presentations created in the co-design sessions. In order to offer clear examples of our analytic procedure, we will discuss three co-design outcomes in detail. Although we were able to identify children's negotiated values in each of the eleven artifacts, these three examples were chosen for didactic reasons because of their diversity. Created in teams of five children who worked together in both sessions, the three co-design outcomes therefore represent the contributions of 15 children. These examples will make clear how artifacts and verbal information can be combined in analysis, in order to arrive at a situated understanding of the values that underpin these co-design outcomes.

8.2.6.2 Outcome 1: Robot Sprietje

Grounding the analysis

The co-design team 'Vivalalalas' translated the design challenge in two concrete problems (see section 4.2): (1) not being kind to one another and (2) forming cliques and excluding others. To improve the class atmosphere, the team assumed everybody should be kind to one another and children should play together instead of forming cliques. Before the creation of the artifact, the team had various initial ideas to solve the problematic situations and improve the class atmosphere.

These ideas were analyzed and categorized in terms of our own values (prevention, self-regulation, safe environment - see Section 4). Three broad categories were created: ideas to

Figure 41: Sprietje, a DJ robot designed by team Vivalalas

facilitate reconciliation or prevent bullying and other problematic class situations ('positive' ideas), disciplinary, and even punishing ideas to remediate such situations ('negative' ideas), and more neutral ideas, that combined elements of the categorization above, or were difficult to categorize for other reasons. The team started out with a clear overweight of positive, preventive ideas compared to negative, disciplinary and more neutral ideas (9 versus 4 and 3). From the pool of ideas they had come up with during brainstorming, the team members collaboratively selected two ideas for further elaboration. For the first problem, not being kind to one another, the team selected a positive, preventive idea as most promising: "organizing a party to bring children together". For the 2nd problem, forming cliques and excluding others, they chose a positive, preventive idea as well: "playing a game together". In the evolution from initial ideas to artifact, the negative, disciplinary ideas completely disappeared in favor of positive, preventive ideas. Further analysis of the co-design outcomes, then, can be grounded in two main characteristics: the translation of the design challenge in two concrete problems (not being kind to each other and forming cliques), and the children's generally positive, preventive attitude to solve these problems.

Listing design features

With their original ideas in mind, the team invented robot called 'Sprietje' (see Figure 41). The co-design team associated several functionalities with their human-shaped robot, including a backpack filled with tips for games, and a drum.

Noticeable functional aspects of Sprietje include his backpack with games, his drum and drumstick. The first main functional feature, the backpack, was made visual/tangible in the form of a cardboard backpack attached to Sprietje's shoulders with ropes. The games or tips themselves, though, were not made tangible: they were mentioned during the presentation, and represented by pieces of paper with names of games written on them (e.g., baseball, play at marbles). During the presentation, the backpack feature was further elaborated upon: if children come up with a good idea themselves (e.g., games you can play with more than two people), Sprietje will collect it in his backpack. The game cards in the co-design outcome only mentioned games, and no 'tips' for a better class atmosphere. However, the 'good idea' the children mentioned during their presentation (games you can play with more than two people) suggests that their ideas about ameliorating the class atmosphere are mostly play-, game- or fun-related. Furthermore, the children mentioned in their presentation that Sprietje eats all 'bad ideas' (e.g. a game for only two participants, so others cannot join) to prevent children from excluding one another. Indeed, the robot has a large mouth, with some sharp teeth - and a large tongue.

A second main functional feature of Sprietje is his drum: the robot holds a drum in one hand and a drumstick in the other. With these attributes, Sprietje is also a DJ. The children mentioned during the presentation that the drum and the drumstick are Sprietje's tools to organize class parties.

Sprietje's non-functional features create a distinct personality for the robot, which is reflected in the fact that the team named the robot, which was implicitly described in the participants' presentation (e.g. "he tells very good jokes"), and more explicitly visualized in the artifact itself. The robot looks funny, friendly and even somewhat rebellious (e.g. haircut, two sharp teeth, etc.). No punishing component was added in the visual appearance of the robot, nor in the children's presentation: when a conflict occurs, he first listens, negotiates a solution and counters the situation by telling a good joke.

Interpreting orientation and organization

Orientationally, Sprietje acts independently from the teacher as a third person. It is a robot with agency and human-like characteristics (e.g. listening and negotiating a solution), not just a toy or a piece of technology that children can use whenever they feel the need to. Moreover, the robot represents an authority: he actively manages the classroom as a whole by guiding children's activities (e.g. eating bad ideas, organizing parties) to optimize the class atmosphere, and he takes an active role in negotiating solutions for conflicts. This active role, however, is somewhat ambiguous. On the one hand, Sprietje facilitates the process of reconciliation between children by negotiating solutions; on the other hand, he also 'eats bad ideas' and tells jokes to defuse conflicts. The latter solutions are a kind of deus ex machina solutions, in which bad ideas are thwarted before they can even present a problem (by eating them), or in which children are distracted from the conflict (through the jokes). In sum, Sprietje presents a positive authority that targets the classroom as a whole by guiding the children's activities and organizing parties. He solves conflicts instantly if he can, and facilitates reconciliation processes if necessary.

Organizationally, the figure of Sprietje represents different aspects of authority. He embodies a solution for two problematic class situations described in 5.2.1: not being kind to one another, and forming cliques and excluding others. The children's solutions to these initial problems both were collective solutions: organizing a class party, and playing a game together. Both these fun, collective solutions are shown clearly in Sprietje's material elaboration: the backpack with good ideas and games, and the drum for the class party are oriented towards the class as a collective. In semiotic terms, both solutions were 'transduced' (see (Kress, 2010) - moved from one to another mode) to the material artifact: this stresses the importance of this aspect of Sprietje. The targeted interventions to facilitate reconciliation, however, were not part of the solutions they initially envisioned: they were mentioned during the presentation, but did not result in specific attributes or functionalities. The only aspect of the targeted interventions hinted at in Sprietje's funny appearance is of defusing conflicts by telling jokes.

In sum, both initial, collective solutions were mentioned during the presentation, and embodied in the artifact. The targeted interventions, however were only mentioned in the presentation, and were not elaborated in the artifact. These positive robot features, and the lack of punishment show the children's generally positive, preventive attitude to solve the problems they selected.

Distilling discourse and values

The co-design team expressed the need to focus on the class group as a whole in a 'no-blame' atmosphere. The analysis of the design features already revealed that positivity, fun and humor are key: this was evidenced by the funny-looking material elaboration of Sprietje, and the children telling about how the robot can tell jokes and organize parties. This hints at a preferred strategy of prevention rather than intervention, as already hinted at in the grounding phase.

Although the robot represents an authoritative figure from an orientational perspective, it is by no means a disciplinary but rather a 'soft authority' acting as a neutral, third party. 'Hard' intervention is never necessary, due to the children's stress on 'motivated' or 'directed' forgetting. When a conflict occurs despite Sprietje's efforts for prevention, he observes and listens without judgment and quickly goes through the social process of negotiating a solution. After a while he will tell a good joke to distract the children, enabling them to move forward without looking for someone to blame: the figure of Sprietje shows that children leave no place for disciplinary punishment.

The children's solution to a bad class atmosphere, and specifically the problems of (1) not being kind to one another and (2) forming cliques and excluding others, can be found in collective, fun activities (class parties, and playing together): positive and preventive ideas that were translated and merged into the figure of Sprietje. Sprietje embodies the children's ideas about a positive authority with a focus on values of collective fun and positivity, de-emphasizing the role of social reconciliation processes, and leaving no place for disciplinary punishment.

8. 2. 6. 3 Outcome 2: Hypnosis machine

Grounding the analysis

The team 'Samenwerkers' (Dutch for 'Collaborators') translated the design challenge mentioned in Section 4 in two specific problems (see section 4.2): (1) 'laughing at others' and (2) 'sad faces in class'. Instead of laughing at others, the team reasoned, children should respect each other and sad faces should be turned into happy ones. The team started out with a clear overweight of preventive, positive compared to disciplinary, negative ideas (8 versus 3). From the pool of ideas they had come up with during brainstorming, the team members collaboratively selected two ideas for further elaboration. For the 1st problem, laughing at others, the team selected a positive, preventive idea as most promising: "Batman guarantees

Figure 42: a hypnosis machine developed by team Samenwerkers

it will not happen often". For the 2nd problem, sad faces in class, they also chose a preventive, positive idea: "hypnotizing the teacher so she will tell funny jokes".

Further analysis of the co-design outcomes, then, can be grounded in two main characteristics. First, the team started out with a clear overweight of positive ideas, and selected two positive, preventive ideas for further elaboration. Second, in both solutions, there is a clear role for an adult figure: Batman in the first, the teacher in the second.

Listing design features

Based on the initial ideas, the team invented the 'Hypnosis Machine' (see Figure 42), a device to be used by the children themselves. The Hypnosis Machine is an industrial looking robust tool, with an aluminum hypnosis disk with a black spiral on it. The children created the machine with much attention for functional (as opposed to aesthetic) detail, such as a robust handle, and an arrow to indicate the direction of rotation. This focus on functionality in the artifact was also evident in the way the children talked about their machine. A large part of the presentation was devoted to the way the tool works, continuously pointing to specific attributes of the artifact, such as the aluminum hypnosis disk and the handle, explaining their functionalities. All non-functional features (arrows etc.) serve to explain the operation of the functional features.

In the second part of the presentation, the team moved beyond the interactive details of their prototype, and explained who would use the Hypnosis Machine. Victims can use the Hypnosis Machine to hypnotize bullies, to make them forget that they are bullies so they will not laugh at them again. Sad children, on the other hand, can use the machine to hypnotize themselves as a way to become happy. Overall, however, the co-design team focused on how the tool should be operated, in line with the industrial equipment-like look of the Hypnosis Machine.

Interpreting orientation and organization

Orientationally, the co-design team explained how the Hypnosis Machine allows sad children or victims of bullying to do something about their own situation. Self-regulation, and interaction between individuals (victim and perpetrator) is key here. The machine focuses on bullies and victims but not on bystanders or the class group as a whole, although the team, in their presentation, mentioned once that a random classmate could use the machine to hypnotize a sad child to make him or her happy again.

This orientational function of the Hypnosis Machine was not evident in its material elaboration: the looks of the tool do not give information on its potential users. Its industrial looks (see above) make the tool not clearly positively or negatively oriented, but very robust nonetheless. If the machine was only used by victims to hypnotize bullies, it could be interpreted as a punishment tool: the victim can take revenge by using the robust, industrial-looking tool. However, the tool can also be used by sad children to make themselves happy again. As children would not be inclined to use a punishment tool on themselves, the hypnosis machine can be interpreted as a restorative tool, rather than a punishment tool. Its main goal is to make children forget why they are sad or why they laugh at others. In this sense, the orientational positioning of the tool as a device for self-regulation is an important aspect only elaborated on in the team's presentation.

In the evolution from initial ideas to artifact, the role of the authoritative figure (Batman preventing children laughing at others and a hypnotized teacher telling jokes) shifted towards self-regulation. The regulatory role of adults in the initial ideas disappeared in favor of a more central role for children. This is a significant orientational shift from top- down towards bottom-up regulation in the co-design outcome. The team did, however, leave some room for third-party authority: the teacher can still intervene when a bully does not want to be hypnotized. In this teacher intervention, the external authority in the original idea returns, but only as a back-up when self-regulation fails. In sum, the Hypnosis Machine is a self-regulation tool to be used by individual children in problematic situations: it solves problems between bullies and their victims, and can make individual sad children happy again.

Organizationally, the team's presentation confirmed the visual elaboration of the artifact: the material and verbal modes reinforce each other in stressing the artifact's qualities as a tool. Moreover, the Machine can be seen as one tool integrating solutions to two quite different problems: being sad (for reasons that are not made explicit) and being bullied. It is not just a tool with two different functionalities to solve two different problems: the same functionality can be used to solve both problems. Organizationally, this is a very tight integration of the double problem definition. As a deus ex machina, the Hypnosis Machine resolves the problems magically and immediately.

Distilling discourse and values

The design features of the hypnosis machine point towards a very functional design intended to be used by individuals. Orientationally, the focus is on the bullying victim, the perpetrator, and the sad child. The rest of the class group is not focused on, and the teacher only intervenes when the self-regulation among the children fails. This shows that the co-design team mainly promoted values of 'self-regulation' and 'victim empowerment', only regulated top-down when things tend to go wrong (e.g. a bully not wanting to be hypnotized). The hypnosis solution, however, does not include social processes of restoration, which in a real-life situation would be necessary. While these social processes are shut out, the tool enables both bully and victim to forget and move forward, rather than to relive the past and to look for someone to blame. This 'motivated' or 'directed' forgetting enables children to start with a clean sheet without an ongoing social process of reconciliation. The tool should therefore be seen as the embodiment of a positive solution to problems in the classroom. As its ultimate goal is empowering its users to resolve conflicts themselves in a blameless, immediate way, the emphasis of team Samenwerkers is on values of self-regulation, empowerment, and positivity (no blame).

8. 2. 6. 4 Outcome 3: The wizard Uki

Grounding the analysis

The 'Ukis'- team translated the design challenge in two problems (see section 4.2): (1) children who brag and (2) children who fight and beat one another. Before the creation of the artifact, they had various initial ideas to solve the problematic situations and improve the class atmosphere. The team started out with an overweight of neutral ideas compared to negative, disciplinary and positive, preventive ideas (7 versus 5 and 3; some of the negative ideas are borderline cases). From the pool of ideas they had come up with during brainstorming, the team members collaboratively selected two ideas for further elaboration. For the first problem, children who brag, the team selected a positive, preventive idea as most promising: "showing that bragging is not good". For the second problem, children who fight and beat one another, they chose a positive, preventive idea as well: "saving someone". As such, the team started out with an overweight of neutral ideas, but eventually selected two positive, preventive ideas for further elaboration.

Listing design features

Starting from their original ideas, the team invented a human-like figure: a wizard with the name Uki (see Figure 43). During their presentation, children explained that during breaks, wizard Uki takes off and flies over the playground to watch children play. Children who do not behave as expected (e.g. bragging and fighting) will be transformed into a frog. This team's artifact has a lot of human-like features (e.g. facial expression, arms, name, etc.). Each detail was discussed in the verbal explanation of the artifact, many of which had a clear purpose beyond decoration: the magic wand is used to transform bad children into frogs, the arrows indicate whether Uki is ready for take off and with the star on its pointy hat, Uki observes children during breaks. However, while every functional detail of Uki was discussed during the presentation (punishing children by turning them into a frog; controlling children by flying over the playground), his general aesthetics (the non-functional features, such as a green cape and a white hat, speckled with red stars) were left undiscussed.

At the end of their presentation, the children explained that the wizard does not really turn children into frogs, and does not really fly over the playground. Instead, the wizard is a toy, to facilitate a role-playing game between victim and perpetrator.

Interpreting orientation and organization

Orientationally, a distinction can be made between Uki's role as a toy mediating between victim and perpetrator on the one hand, and his role within the role-playing game itself. Within the game, wizard Uki has a supervisory and punishing role: nothing goes unnoticed because of the star on his head. While observing the children, Uki makes a clear distinction between good and bad behavior. Perpetrators are in the center of his attention, whereas victims and bystanders seem to be neglected. Perpetrators, when spotted, are turned into frogs as a form of punishment. However, as a toy mediating between victim and perpetrator, Uki's role changes: Uki no longer has agency but aims to empower victims in a playful manner. Victims use the toy to initiate restorative practices with their perpetrators. Through a role-playing game in which the wizard transforms the perpetrator into a frog, the perpetrator comes to realize the effects of his or her behavior on the victim. The spell can only be broken if the perpetrator changes his or her behavior for the better. Although the game is centered on punishment, the eventual goal is to reconnect victim and perpetrator, using the role-play during the process of reconciliation.

Organizationally, the initial punishing, controlling tone of the co-design team's explanation contrasts with the general aesthetics of the wizard. Uki looks cheerful and a lot of effort was put in decorative details such as a pointed hat with a star, a magic wand and a long green cape. His white hat and wand, speckled with red stars, and his green dress create an overall friendly, non-threatening look. Moreover, the wizard looks friendly: he has a smile on his face, and a small beard. The look of the wizard was commented upon by children from other teams, who called the wizard pretty. However, Uki's role as a role-playing toy resolves the apparent mismatch between the wizard's looks and the punishing, controlling role. In this light, the apparent paradox between Uki's cheerful appearance and his disciplinary, authoritative role is resolved.

The solutions for the two initial design problems (bragging and fighting) have been merged into one wizard. Uki does not really have attributes that addresses either of the issues directly. Rather, the solution to the bragging problem (showing that bragging is not good) has been extended to a general reconciliation through a role-play in which victims can bring perpetrators to new insights in a playful and friendly way, showing that all kinds of bullying behavior is not good. The solution to the fighting and beating problem initially was in saving someone. This solution is embedded within the fictional world of the role play: the children talked about how bullies can no longer hit anyone because they have been turned into a frog. Outside of the fictional world, however, the team's solution to the fighting and beating problem also comes down to the role play: "you show that that [behavior] is not good, by saying: he did something [bad], and now he is a frog, and then you say: I'll set you free if you never do it again. […] Then he [the perpetrator] also knows that that is not good, and he doesn't like it himself."

Uki's cheerful appearance highlights or gives special weight to this playful layer, an aspect that was somewhat underexposed in the presentation, where the content of the game (turning bullies into frogs, etc.) was stressed. In sum, Uki embodies a generic solution that can solve different types of problematic behavior, including the two original design problems.

Distilling discourse and values

The team proposed an anthropomorphic figure, a wizard, with different functionalities to supervise and influence the children's behavior. Although the role-playing game seems to be centered on punishment, the values of empowerment, restoration, and, ultimately, fun, are key in the restorative game. Whether the artifact can actually lift off to observe children's behavior or whether this function is part of the role-playing game initiated by victims, remains unclear. Supervision, however, seems to be another key value of the team's understanding of how to improve the class atmosphere and strengthen social cohesion.

8.2.7 Discussion

To illustrate the GLID method, this paper discussed a case study in which children aged 9 to 10 were involved in a series of co-design activities. The aim was to generate ideas for future technologies and practices that would cope with bullying behavior in school. The co-design techniques served as constructivist tools to assist investigations of 'what may be' rather than simply 'what is' (Lee, 2014). The simultaneous act of making and reflection in the co-design activities increased children's awareness about the complexity of bullying behavior and how to establish and maintain a good class atmosphere.

Although children negotiated a solution with their team members while being engaged in making activities, they did not explicitly discuss personal values and value trade-off

Figure 43: the wizard Uki designed by team Ukis

processes. This may at least partly be due to children's developmental characteristics. The participants were 9 to 10 years old and although they were verbal and self-reflective enough to discuss what they were thinking, according to Piaget children's abstract thinking skills are only beginning to develop at this age (Piaget, 1970). This implies that, when it comes to abstract concepts such as 'values', 9- to 10-year-olds may still have a difficult time verbalizing their thoughts and much of what they say needs to be interpreted within the context of concrete experiences (Piaget, 1970).

Co-design techniques proved to be particularly useful here, because the making activities stimulated ad hoc reflection and children did not have to think about complex and abstract issues without specific reference materials. In addition, since values are critical motivators for people's attitudes and behavior (Rokeach, 1973; Schwartz, 1992), the way in which children approached the design challenge and co-constructed a solution told us something about their values. The artifact and its verbal explanation were the result of a collective sense-making process in which children's negotiated values were embedded, be it implicitly. With GLID, we were able to combine both modes of communication (i.e., artifacts and verbal information) in a coherent analysis in order to arrive at a situated understanding of the values that underpin these co-design outcomes.

The results showed that some of the team's ideas and suggestions are not very realistic (e.g. the hypnosis machine) or hard to reconcile with educational goals (e.g. directed forgetting as opposed to restorative practices). In addition, some co-design teams proposed design ideas that seem contradictory at first sight (e.g. victims turning bullies into frogs vs. a robot that listens to what both victim and perpetrator have to say). Combining these different suggestions into a holistic design in the further design process is challenging. However, by looking at the values embedded in co-design outcomes with GLID, we could go beyond the surface level of children's ideas and whether or not these ideas were realistic or justifiable from an educational perspective.

GLID furthermore enabled us to identify potential value conflicts between teams and other stakeholder groups. For instance, whereas we focused on prevention and self-regulative behavior to create a safe class environment, most teams combined prevention and intervention measures into one integrated approach. The teams also hinted at a mix of top-down and bottom-up regulation to safeguard a positive atmosphere, yielding a different view on how to empower children. As for the teams' emphasis on positive reconciliation within a no-blame atmosphere, this aligned well with our goal to create a safe and positive environment for children. Although such a comparative analysis is beyond the scope of this paper, we see it as a main strength of the GLID method. Such a comparative analysis also offers interesting opportunities to debrief children about the results.

In sum, with GLID, design researchers can identify values and potential value conflicts between children and other stakeholders. This type of knowledge is useful to more accurately define the design problem and gain insight in the impact of potential solutions on the lives and environment of children. However, since GLID is time consuming, design researchers looking for inspiration in the form of workable design ideas are advised to take a descriptive perspective (see section 2.1.1) to analyzing co-design outcomes.

In the case study described in this article, GLID was not applied as a single method-formula or a generic process. Rather, GLID served as a reflective tool that was carefully adapted to the context, including our own values. For instance, in the grounding stage, children's ideas were analyzed and categorized in terms of the values prevention, self-regulation and safe environment, resulting in the categories 'positive or preventive', 'negative or disciplinary' and 'neutral' ideas. These values not only permeated the grounding step but all four steps of the analysis. Since the process of interpretation is not value free, multiple and equally valid interpretations can co-exist. This means that, when other researchers would have used GLID to analyze the data, it could have resulted in different readings. GLID does not want to scientize this process in a positivistic sense, but aims to increase rigor and transparency by gradually constructing interpretations in a well-substantiated manner.

As multimodal analyses in modes of communication and metafunctions can be applied to all types of communication, the GLID method can be used to analyze the outcomes of various types of co-design processes. For instance, the method can also be used in cases where the co-design outcomes take other forms besides tangible outcomes. In this paper, we focused on the material and verbal modes, but other modes can be included as well to arrive at a coherent understanding (e.g. embodiment, process of negotiating meaning). When analyzing co-design outcomes with GLID, it is essential to pay attention to an appropriate selection of modes, and to analyze how these modes co-construct the co-design outcome, how they emphasize or downplay specific aspects of the design, and how this design as a whole mediates between different actors. Using the GLID method in other co-design contexts, with other types of co-design outcomes, however, remains an area for future work.

8.2.8 Conclusion

In this paper, the GLID method was presented to analyze co-design outcomes in a transparent and systematic way. GLID aims to deduce negotiated values embedded in co-design outcomes by integrating different modes of communication (e.g. verbal, material) in a coherent analysis. GLID thereby addresses two shortcomings found in academic literature: (1) a unilateral focus on the verbal explanation while neglecting the material dimensions of co-design artifacts, and (2) a lack of transparency when interpreting children's contributions.

Relying on GLID, first, the co-design outcomes are situated against the background of the participants' initial suggestions (Grounding). Next, all design features and their immediate functional consequences are listed in detail, providing a basic overview (Listing). Afterwards, these features are interpreted on an orientational and organizational level (Interpreting). Finally, the discourse and underlying values are analyzed (Distilling). Deducing these values is not a linear deductive process, but an interpretative process that involves several iterations of going back and forth between the different steps. Whereas the first two steps of the GLID method are more descriptive in nature, the final two steps are the most interpretative ones. Using GLID, a situated understanding of children's values is achieved, because the values can be traced back to their origins, that is, certain functionalities and their desired consequences. At the same time, by going beyond the surface level of ideas, a level of abstraction is added to the analysis, resulting in a rich and empathic understanding of what genuinely drives and motivates children.

We call upon researchers within the PD and CCI community to apply and validate the GLID method in different types of design projects. These applications will help us to critically examine and further refine the GLID method.

9. Co-design toolkit

The co-design toolkit described in this section is the capstone of this PhD research. The toolkit is aimed at design researchers and CCI practitioners, but it may also be useful for teachers who want to improve children's Design Thinking and collaboration skills, or in other design fields besides CCI . The first part of the toolkit (CoDeT) tackles the problem of challenging intragroup or co-design dynamics (cf. RQ1a), and the second part (GLID) addresses the problem of analyzing co-design outcomes in a structured way and beyond the surface level of children's ideas (cf. RQ1b). Together, CoDeT and GLID offer a holistic co-design approach. The CoDeT procedure provides instructions for how to prepare and conduct co-design activities with children, whereas the GLID method can be relied on to interpret the outcomes of these co-design activities.

After introducing the toolkit, key concepts applied in the CoDeT procedure are discussed, and a list of potential challenging group dynamics is presented. These dynamics can be mitigated when following the procedure. Then, the different steps of CoDeT are explained in a what-why-how structure, and some additional guidelines for facilitators are provided. As for the GLID method, first the underlying rationale (i.e. to arrive at children's values embedded in co-design outcomes) and some theoretical concepts that form the backbone of the method are explained. Then, the different steps of GLID are presented in a what-why-how structure, and additional guidelines are provided for a applying the method.

9.1 Introduction to the toolkit

9.1.1 Co-design

In this toolkit, co-design is referred to as any form of collective creativity as it is applied across the whole span of a design process (Sanders and Stappers, 2008). As a method or technique, co-design relies on two major assumptions:

- everyone can be creative but many are not in the habit of using or expressing their creativity,
- making creativity more open and social through participatory processes increases positive outcomes (e.g. the range and quality of options).

9.1.2 The co-design toolkit

The goal of this co-design toolkit is to design future technologies and practices for children with children. Although not limited to, the toolkit is especially useful to generate ideas and co-construct knowledge at the early, fuzzy stages of the design process where the design problem is still being defined. The toolkit consists of two major parts:

The CoDeT (Collaborative Design Thinking) procedure focuses on organizing and conducting co-design sessions with children. The procedure has a dual goal: scaffolding Design Thinking and facilitating effective collaboration.

The GLID (Grounding, Listing, Interpreting, Distilling) method focuses on the analysis of co-design outcomes resulting from CoDeT beyond the surface level of children's ideas. The method integrates textual, tangible and other co-design outcomes into a structured and coherent analysis. Together, CoDeT and GLID offer a holistic co-design approach to involve children as design partners at the early stages of technology design.

9.2 The CoDeT co-design procedure

9.2.1 Rationale

As a general guideline for using the CoDeT procedure, keep in mind that children are cognitively and emotionally different from adults, and will most likely have no or only little experience with Design Thinking and/or collaborating in a team. Therefore, the CoDeT co-design procedure aims to:

- Scaffold children's creative abilities by introducing Design Thinking mechanisms
- Facilitate children's collaboration by structuring work-group features and mitigating challenging intragroup dynamics

9.2.1.1 Scaffolding Design Thinking

Design Thinking refers to transferring designerly methods, tools and processes to other areas or people who are not trained as a designer; in this case children. A central feature of Design Thinking is the constant alternation of expanding the design space through idea generation (i.e., divergence or creating choices) and reducing the design space through selection of ideas (i.e., convergence or making choices). Generating design ideas is also referred to as projective thinking and selecting ideas as reflective thinking on the impact of the projection (Kimbell, 2000). With CoDeT, children are enabled to engage in a Design Thinking process and co-construct ideas for future technologies and practices.

9. 2. 1. 2 Facilitating effective collaboration

Collaboration refers to situations in which two or more children work together, and perceive that their individual efforts are needed to attain a shared (design) goal (Johnson and Johnson, 2005). Whether or not children are able to collaborate constructively depends on many factors including the size of the group, the diversity of the team members, and the child-to-adult ratio. As one or more of these factors increase, the likelihood of challenging group dynamics between children increases as well, which may hamper their collaborative and creative efforts. With CoDeT, children are enabled to collaborate constructively and in mutual respect for one another.

9. 2. 1. 3 Challenging group dynamics

Group dynamics are a system of behaviors and psychological processes that may occur within a social group (intragroup) or between social groups (intergroup) (Lewin, 1948). In this toolkit, the term co-design dynamics is used to refer to a system of intragroup dynamics occurring within a group of participants engaged in any form of collective creativity in the design process. These intragroup dynamics can hamper children's collaborative and creative efforts in co-design activities. Managing these intragroup dynamics is a question of finding the right balance, rather than attempting to completely prevent or eliminate them. With the CoDeT procedure, the following challenging co-design dynamics can be mitigated:

Unequal Power

Some children come to the co-design tasks with higher status than others and can exert significant influence on the group process, either positively or negatively. For instance, by misusing their higher status, these children can force their design ideas and suggestions on the team without a process of negotiation. This makes it difficult for other team members, especially shy or less verbal children, to voice their opinions and contribute equally to the group process.

Apart Together

The Apart Together dynamic occurs when children work individually instead of negotiating a design solution. These children hold on to their own interests and ideas, and often end up building their own prototype. When the whole team is engaged in this behavior, the result is a disconnected mix of individual designs without an overall design vision. Possible causes are insufficient interpersonal and small-group skills, a lack of social cohesion (i.e., affect towards other team members) and a lack of task cohesion (i.e., commitment to the group goal).

Free Riding

Children who devote less effort and who do not contribute substantively to the achievement of the group goals, perform Free Riding behavior. These children typically do not feel as responsible or capable to contribute compared to the other team members. Free Riding may result in tensions and conflicts within the team because it reduces feelings of satisfaction, and those who do not loaf, feel that they have been taken advantage of.

Laughing Out Loud

Laughing Out Loud happens when there is an unwillingness to take the design task at hand seriously, resulting in a disruptive atmosphere. The problem with the Laughing Out Loud dynamic is not that children laugh a lot and have fun, which can have a positive impact on collaboration, but the lack of reflection and substantive conversations about the design challenge. Possible causes are a lack of intrinsic motivation and problem ownership, or insecurity about one's capabilities to contribute.

Dysfunctional Conflict

Different types of conflicts may occur between team members: (1) conflicts caused by personal incompatibilities, (2) task-oriented conflicts about what should be done, and (3) process-oriented conflicts about how it should be done. Although moderate amounts of conflict can be useful to create more energy around sharing diverse information and viewpoints, children are not always capable of managing differing voices productively, leading to polarization within the team (e.g. defensive behavior, inflexibility, lack of trust).

Groupthink

Groupthink happens when children are reluctant to criticize each other's ideas. This emphasis on concurrence seeking leads to poor decision-making whereby the team rushes too quickly towards consensus, neglecting valuable choice alternatives. Especially novel and original ideas may not make it to the final selection, because they are riskier and more uncertain. Groupthink typically occurs in cohesive teams that lack diversity. When everybody gets along, team members see the group as more effective than it really is.

9.2.2 Applying the CoDeT procedure

To apply the CoDeT procedure, a number of decisions have to be made regarding the design challenge, the age group, and the location for the co-design activities:

- Design challenge: a broad theme is preferred over a narrowly defined problem. This way, children can co-determine the direction and outcome of the design project.
- Age group: the CoDeT procedure targets 9 to 10 year olds, but can also be used with slightly younger or older age groups.
- Location: the procedure is especially useful at high child-to-adult ratios (e.g. 1 adult for 15 to 20 children) as in a school context.

Once these decisions have been made, the different steps of the CoDeT co-design procedure have to be prepared. For each of these steps, (a combination of) different techniques can be used. The different steps are: (1) Introduction, (2) Sensitizing, (3) Scaffolding collaboration, (4) Defining a point of view, (5) Group processing, (6) Ideation, grouping and selection, (7) Elaboration through making, (8) Presentation and peer jury, (9) Wrap up (see Figure 45).

9.2.2.1 Step 1: Introduction

Have a dialogue about what design researchers do and why. Afterwards, explain the design challenge and why children's help is needed. Also, give a quick overview of the co-design activities, and clarify what will be done with children's input afterwards. A useful tool to prepare this initial introduction is the CHECk tool (Read et al., 2013; Van Mechelen et al., 2014b). After the general introduction, provide the children with one or more assignments to increase their understanding of the design challenge. This step is referred to as sensitizing.

9.2.2.2 Step 2: Sensitizing

What?

Triggering children's reflection about the design challenge, either individually as preparation for the co-design activities and/or as an initial group activity.

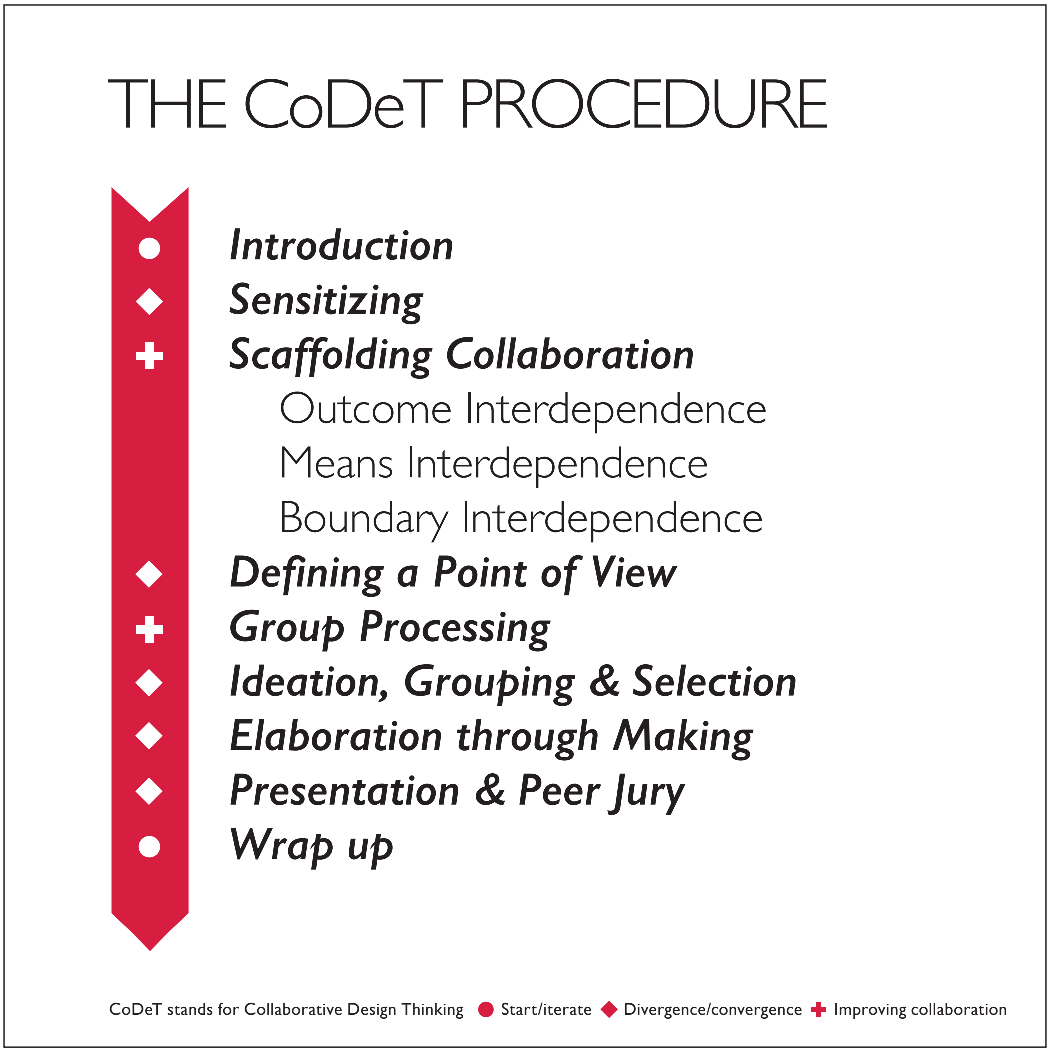

Figure 45: The different steps of the CoDeT co-design procedure to design technology for children with children

Why?

The goal of the sensitizing phase is to stimulate children's reflection and curiosity about the design theme, which, at this point, is still rather broad and fuzzy (Sleeswijk Visser et al., 2005). Through one or more hands-on tasks, children are encouraged to reflect on the design challenge and deepen their understanding of the problematic situation, either individually or as an initial group activity. These preparatory tasks give room for thought on how the design challenge can be addressed (cf. incubation). In addition, sensitizing creates a desire to know more about the design theme, and increases feelings of problem ownership. In the sensitizing phase, the possibility space expands for the first time (divergence), which means that a wide range of options and directions are considered for further investigation.

How? Examples

Different techniques can be used to sensitize children. A wide variety of assignments can be used, ranging from visualizing the design challenge with a drawing, interviewing or observing relevant persons, gathering existing information about the problematic situation to be solved, keeping track of relevant experiences and thoughts in a diary, and so on.
It is advisable to make these tasks hands-on, playful and creative, and to add an element of surprise to keep children engaged (e.g. putting assignments in sealed envelops). It is also important to make clear arrangements about how and when to collect the results. For instance, give children individual assignments which they work on at home in their free time. Then, use (some of) the results of these individual assignments as input for the co-design activities by initiating a team discussion.

9. 2. 2. 3 Step 3: Scaffolding collaboration

To scaffold collaboration, a situation is created in which children perceive that they have to work together to accomplish a shared design goal, and that individual efforts are important for the entire team. This situation is characterized by a positive correlation between children's goal attainments and is referred to as positive interdependence. In contrast, when children are competitively linked, the goal attainment of one team (e.g. winning the prize for best design idea) will result in failure for the other teams. This is referred to as negative interdependence (Johnson and Johnson, 2005).
There are three, complementary types of positive interdependence: outcome, means and boundary interdependence. By structuring all three types at the start of the co-design activities, children will be encouraged to collaborate constructively and in mutual respect for one

another. For explanatory reasons, the three types of interdependence are explained one after the other, but in practice the different techniques can be used interchangeably.

Outcome interdependence

What?

Children experience outcome interdependence when they share one or more goals, and when they perceive that working together will improve their chances to attain these goals.

Why?

When outcome interdependence is structured adequately, a situation is created in which team members can only achieve their goals if the group as a whole succeeds. These goals can either be defined top-down or through negotiation. If design researchers decide upon the goals, these should relate to children's experiences in order to be meaningful. A better way is to involve children in defining the direction and the outcome of the co-design process. This will increase feelings of problem ownership, task cohesion and a willingness to achieve the shared goals, important to prevent the Laughing Out Loud dynamic. Outcome interdependence (extrinsically) motivates children to take responsibility and encourage each other to exert maximum effort.

How? Examples

Storytelling to present the design challenge

A first way to implement outcome interdependence is through storytelling. Think of a story, either fictional or not, to contextualize the design challenge with lively, detailed examples, and tell it to the children at the start of the co-design session. This story has to function as an anchoring event for the co-design activities. Depending on the project, the design challenge embedded in the story can deliberately be kept broad to leave room for problem finding to occur. Teams can define a problem based on their interpretation of the story (see section Defining a point of view), for which they then develop a suitable design solution.

Documenting the design and collaboration process

Hand out design diaries, one for each team (see Means interdependence for composing teams), in which children document their process from problem statement to solution. This way, the focus expands from developing a tangible solution to also include the process. Keeping track of their progress and experiences stimulates reflection and dialogue among team members. Moreover, this documentation will help teams to prepare a presentation at the end of the co-design activities, and motivate their design decisions (see section Presentation and peer jury).

Individual and team incentives

Combine individual incentives with team incentives. Explain which incentives will be handed out at the end of the co-design activities, and under which conditions. Providing incentives for doing well as a team can strengthen children's willingness to collaborate. For instance, children can receive an individual design certificate or any other tangible reward after successfully running through the different design stages with their team. In addition, a winning design can be chosen among the different teams (see sections Boundary interdependence and Peer jury).

Means interdependence

What?

Children experience means interdependence when they depend on one another for resources and abilities to achieve the shared goals.

Why?

Structuring means interdependence between team members enhances communication and collaboration because team members have complementary skills, separate roles and responsibilities, and/or have to share a limited amount of resources. As a consequence, children feel more responsible to contribute to the group process and need each other to achieve the group goals. When means interdependence is implemented adequately, it can mitigate the Unequal Power and Free Riding dynamics in co-design teams.

How? Examples

Small, heterogeneous teams

Compose small (e.g. 4 to 6 children) heterogeneous teams in which children with different skills work together (e.g. verbal, creative, motor, analytic skills). However, avoid placing children who do not get along in the same team. Dividing children into teams is best done with the help of the teacher who is better aware of the social dynamics in the class group, and the strengths and weaknesses of each child.

Different roles and responsibilities

Initiate a short class conversation about effective collaboration and good communication, and, afterwards, discuss different roles and responsibilities that have to be divided among the team members. These roles can be conceptual in nature (e.g. looking through someone else's eyes) or practical (e.g. time keeping).

At least one of these roles should focus on good communication (e.g. conversation soldier). This role can be linked to a discussion etiquette that children come up with during the class conversation, and that includes tips for turn-taking, good questioning and how to provide arguments. Additional roles can also relate to certain rules of the game, such as taking good care of the prototyping materials (material guard), paying attention when instructions are given (silence captain), filling in the design diary after each activity (diary major), and keeping track of the time (time keeper).

Make sure that children do not choose these roles randomly, but either come up with the roles themselves (i.e., as a result of the class conversation) or, when they are top-down defined, negotiate which role is best suited for whom. Also, clearly communicate the function and responsibility of each role (e.g. summarized on a badge), and give children time for practice before moving on to more complex design tasks.

Limiting materials

Limit the amount of some materials per team (e.g. one pair of scissors and glue stick per team). This technique can encourage children to discuss their design approach more thoroughly, because they have to negotiate who can use which piece of material and for how long. Make sure to apply the technique wisely to avoid process conflicts. For instance, make someone responsible for the division of prototyping materials (e.g. material guard), so that each team member can contribute equally to the design process.

Boundary interdependence

What?

Children experience boundary interdependence when they share a team identity, and when they are intrinsically motivated to help one another to succeed.

Why?

When boundary interdependence is implemented adequately, children will perceive a shared identity, which improves the teams' social cohesion. When team members feel affect towards each other, they are more willing to help each other in achieving group goals, and not merely because it is in their own interest to do so. The more heterogeneous a team in terms of skills and backgrounds, the more attention should be devoted to creating a shared identity. Teams that lack social cohesion easily fall victim to the Apart Together dynamic and Dysfunctional Conflicts.

How? Examples

Proximity and inter-group competitive mechanisms

First, create physical boundaries between the in- and out-group (i.e., proximity) by separating teams in space. Then use inter-group competitive mechanisms to further strengthen these boundaries. Explain that a winning design will be chosen by the end of the co-design activities, meaning that teams will compete against each other (see section Presentation and peer jury). However, when using inter-group competitive mechanisms, make sure that all children feel as if they have accomplished something with their team (e.g. by handing out individual design certificates).

Creating a shared identity through teambuilding

Use all kinds of teambuilding activities to improve social cohesion and commitment towards the team. This is especially useful to reverse feelings of disappointment when children are assigned to a team (e.g. based on abilities) and prefer to be in another team. In addition, teambuilding activities give children the opportunity to become used to their new role as design partners. A possible teambuilding activity is to ask children to think of a group name and a slogan, and to design a logo afterwards, which each team then presents to the other teams to which they are competitively linked.

As an example, the techniques for implementing outcome, means and boundary interdependence can be applied in the following order at the start of the co-design activities:

- Compose heterogeneous teams of 4 to 6 children; give each team a separate spot
- Use a storytelling approach to explain and contextualize the design challenge
- Hand out the design diaries, one for each team, and explain their purpose
- Talk about the individual and team incentives; explain that teams will compete
- Discuss good communication and collaboration; define a discussion etiquette
- Discuss different roles and responsibilities that are to be divided in each team
- Hand out a bag with materials; explain why some materials are limited
- Initiate teambuilding activities during which children can practice their roles

9. 2. 2. 4 Step 4: Defining a point of view

What?

Teams define a problem statement that determines the future focus of the co-design activities. They therefore rely on the insights from the sensitizing phase.

Why?

The point of view reflects the co-design team's perspective on the design challenge. Whereas the design challenge is usually top-down defined by the project and the design researchers, here children reinterpret it to make it their own. Each team therefore synthesizes the insights from the sensitizing process (e.g. through a group discussion), resulting in a concrete problem statement and a list of criteria that should be met to solve the design problem. As such, the future focus is determined and feelings of problem ownership are created, further strengthening outcome interdependence among the team members. Defining the point of view is a first selection phase (convergence), in which the possibility space is drastically reduced.

How? Examples

Problem statement and criteria

As a warm up, ask teams to discuss (some of) the results of the individual sensitizing assignments. Afterwards, instruct teams to define a problem statement (one per team) in the form of a "How could we…" question based on their interpretation of the story (see Outcome interdependence). When all teams has defined a problem statement, let them clarify why their design problem is worth solving. Probing for why-questions stimulates reflection and discussion, and can reveal children's underlying motives for their choices.

Next, ask teams to think of different criteria that should be met to solve their design problem (e.g. a list of requirements and wishes). When finished, instruct them to write the criteria, problem statement and main motivation in the design diary.

Visualization

Finally, explain that each team has to visualize their problem statement with a drawing or collage. To execute this task, give each team a (new) bag with materials, some of which are limited (e.g. pencils, colored paper and markers). When all teams are finished, ask children to present their visualization, problem statement and criteria to the other teams, who can ask questions and provide constructive feedback.

9.2.2.5 Step 5: Group processing

What?

Teams reflect upon the group process and make decisions about which actions to continue or change in the remaining co-design activities.

Why?

Children may not yet be used to working in a team and often lack interpersonal and small-group skills to deal with differing voices, which may lead to Dysfunctional Conflicts. To continuously improve their collaboration over time, at regular intervals children should discuss how well they are achieving their goals. This reflective process results in a posteriori knowledge about effective collaboration and good communication, and how it can be improved. In turn, group processing positively impacts children's interpersonal and small-group skills as well as the motivation to use these skills, and increases feelings of commitment and responsibility towards the team.

How? Examples

Initiate group processing halfway the co-design activities, and explain why it is important that teams discuss their collaborative efforts. Group processing should be framed positively and personal attacks should not be allowed, because that can be detrimental to the group atmosphere. For instance, let children think of three actions that were helpful and one action that can be added or improved for the whole team (e.g. starting with the words "I wish that…").

When children fulfill different responsibilities within the team, let them refer to these roles (e.g., material guard, time keeper, conversation solider) in order to make potential criticism less personal. This will increase the likelihood of constructive dialogues about the group process and how it can be improved during the remaining co-design activities.

Once each team has come to an agreement about how to improve the collaboration process, ask to write their conclusions in the design diary as a reminder. Afterwards, initiate another class discussion (see also Means interdependence) about effective collaboration and good communication, and what children have learned so far. If necessary, alter the discussion etiquette for which the communication soldier is responsible based on the outcomes of this discussion.

9. 2. 2. 6 Step 6: Ideation, grouping and selection

What?

Teams generate a wide range of ideas to solve the design problem defined in the point of view phase, and, afterwards, select a few ideas for further development.

Why?

Separating the divergence and convergence of ideas is considered good practice for divergent thinking. Therefore, as many and varied ideas as possible are generated before evaluating these ideas based on the criteria determined in the point of view phase. During ideation, the possibility space typically expands to its maximum, only to reduce drastically during the selection phase.

Ideas rarely come from nowhere and are often based on a recombination and mutation of previous insights and experiences. The process of sensitizing and incubation is therefore crucial, as well as turning ideation into an open and social process during which children build on each other's ideas. As for the selection, special attention is needed to safeguard original ideas. Due to their novelty it is difficult to predict whether these ideas will work (i.e., solve the design problem), which makes them both risky and vulnerable.

How? Examples

Ideation

Introduce one or more divergent thinking techniques (e.g. brainwriting, superhero brainstorming, gamestorming) that each team will use to generate a broad variety of ideas in a relatively short amount of time. Whatever the technique, make sure to include rules for ideation such as in Osborn's (1953) brainstorming technique: "do not criticize", "quantity is wanted", "combine and improve suggested ideas", and "say all ideas that come to mind no matter how wild". Other rules that can be added are "be visual" and "stay focused on topic". In addition to these and other rules, it is advisable to start with a warm-up exercise, and to alter between individual thought (e.g. short individual brainstorm) and building on each other's ideas (e.g. passing on written ideas to inspire other team members).

Grouping and selection

To select a few ideas for further elaboration, similar ideas should first be grouped together and evaluated based on the criteria defined earlier (see Defining a point of view). This will increase understanding and ownership of the ideas. To preserve unusual ideas, ask teams to add the criterion originality and novelty to their list. Afterwards, let teams select a small number of ideas through (anonymous) voting.

9. 2. 2. 7 Step 7: Elaboration through making

What?

Children synthesize and further develop the selected ideas into one or more visual representations or prototypes.

Why?

In the elaboration through making phase, the teams synthesize and further develop the selected ideas into one or more coherent concepts. These concepts offer a solution for the problematic situation defined in the point of view phase, or at least improve the situation. In order to develop these concepts, new details and alternatives are to be considered, meaning that the possibility space slightly opens up once more. Elaboration is a hands-on process in which teams create visual representations of selected ideas with low-tech prototyping materials. The act of making stimulates reflection and helps to identify areas that need additional thought or specification.

How? Examples

Encourage teams to first make a plan for how to approach the task and what kind of materials they need. Then, ask them to quickly develop different models or prototypes (e.g. scaled 3D model, photo story, role-play or video) to integrate one or more selected ideas. Afterwards let them choose the most promising model or prototype based on the same criteria that were used to select ideas and that were defined in the point of view phase. The selected model or prototype can then be further refined.

When time is limited let teams build only one model or prototype. Explain that the selected ideas can be synthesized into a new idea, in analogy with mixing two colors into a new one (e.g. mixing red and blue results in purple). Using visual metaphors like these increases children's understanding of how to alter between divergence and convergence. In order for teams to develop a coherent concept, ask them to think of a title and tagline first.

As for the materials that teams can use, provide a bag with low-tech prototyping materials (e.g. scissors, cardboard, aluminum dishes, ropes, colored paper, glue, Styrofoam) for each team. As in previous co-design activities, some of these materials can be limited to enhance communication between team members (see Means interdependence).

9.2.2.8 Step 8: Presentation and peer jury

What?

Teams present their final prototype to the other teams who can ask questions and provide constructive feedback.

Why?

At this stage, teams present or show their prototype to the other teams to gather feedback. In most cases, the other teams represent the envisioned users of the prototype, which makes their feedback especially valuable. In addition, design researchers ask open-ended questions to clarify certain design decisions, and they moderate the discussions. Afterwards, teams can use the feedback to revise their current prototype and, if necessary, reconsider earlier made design decisions. As such, collecting feedback from peers becomes an iterative process of evaluation (convergence) and adaptation (divergence).
In addition, a peer jury creates a sense of group accountability, because the team as a whole is held responsible for doing their work and attaining the shared goal. Group accountability strengthens outcome interdependence, and helps to mitigate the Apart Together dynamic because there are consequences for doing well as a team.

How? Examples

Presentation

Ask each team to prepare a presentation about their final model or prototype. As an intermediate step, let them first write a short summary in their design diary, including the major strengths of their invention and how it addresses the design problem (see Defining a point of view). This summary should include the title and tagline they thought of in the previous step (see Elaboration through making). Also, encourage teams to select a few process highlights to talk about during the presentation (e.g. group processing, criteria, selected ideas), based on what they have documented in their design diary.

Peer jury

When one team is presenting, the other teams function as a jury. They are encouraged to listen carefully, ask questions and provide constructive feedback. Afterwards, each jury team gives individual scores for predefined criteria (e.g. quality of the concept, look and feel, presentation), and provides arguments for their scores. For instance, by filling in a form with questions such as: “Does the design solve the problem defined by the team? Why or why

not?” and “What do you like about the look and feel of the design? What would you like to change?”. These questions stimulate reflection and discussion among team members, and provide deeper insights in how teams value each other’s designs.
Finally, add up the individual scores for each presented design to identify the winning team (see Boundary interdependence) that receives a design cup or any other tangible reward. In addition, hand out design certificates to all participating children for their achievements

9.2.2.9 Step 9: Wrap up

To wrap up the co-design session, explain what will happen with children’s input, and if and how they will be involved in the next phase of the design process. Also briefly discuss children’s experiences about working in a team and being design partners.

9.2.3 Additional guidelines for facilitators

9.2.3.1 Adapt to the class- and school culture

Have an introductory meeting with the teacher (and school staff) to gain insight in the school- and class culture, and adapt the CoDeT co-design procedure accordingly. Depending on the possibilities, the procedure can be executed as a whole day session, or divided into multiple sessions in two or more days. In the latter case, make sure to end each session with group processing, in order for teams to improve their collaboration in the next session.
Keep in mind that on the spot adaptations are probably needed (e.g. with regard to timing), and that this requires a flexible attitude. Also, remember that the procedure is a means and not a goal in itself.

9.2.3.2 Encourage promotive interactions

Facilitate promotive interactions during the co-design activities, for instance by positively reinforcing children and gently pointing towards their role and responsibility in a case of Free Riding. However, do not assess children individually for doing their share in the team, because this may hamper creative thinking. Instead, aim for dialogue and, when Dysfunctional Conflicts occur, facilitate children to come up with a solution instead of imposing one right away.

Also, keep in mind that although conflict is often perceived as a negative force, with collaboration at the other end of the continuum, its impact is more nuanced than that. Moderate amounts of conflict can be useful to avoid the Groupthink trap, because more energy is created around sharing diverse information and viewpoints. Therefore, as a facilitator, it is important to safeguard room for different opinions within the team.

9.2.3.3 Participate actively

Actively participate in discussions and the creation process by asking in-depth and non-judgmental questions. For instance, ask for arguments to clarify an opinion or a certain design decision. This will stimulate reflection and substantive dialogue about the design problem and how it can be addressed. In case there are fewer adults than groups of children, rotate between teams during the co-design activities.

9.3 The GLID analysis method

9.3.1 Rationale

The GLID method integrates the material dimensions of co-design artifacts and their verbal explanation in a structured and coherent analysis . The method goes beyond a descriptive analysis of children's ideas and aims to identify the values embedded in co-design outcomes resulting from the CoDeT procedure.

9.3.1.1 The concept value

The concept value has been used in psychology and the social sciences to explain motivational basis of attitudes and behavior, and refers to certain end states or modes of conduct that people consider important in life. Whereas someone's needs are many and often change quickly, values are few and relatively stable (Rokeach, 1973; Schwartz, 1992). Therefore, in co-design activities, it is useful to go beyond participants' concrete ideas and suggestions to arrive at an empathic understanding of the values at stake in that situation. Especially at the early, fuzzy stages of design, this type of knowledge is useful to more accurately define the design problem and inform potential solutions.

9.3.1.2 Co-design as a negotiation of values

Following the CoDeT co-design procedure or a similar variant, children define a problem statement and co-construct a solution in small teams. They thereby alternate between projective thinking (what could be), and reflection about the consequences of their projection. In this process of collective sensemaking, children either implicitly or explicitly negotiate the values they hold. To this regard, the GLID method relies on two premises:

- Co-design outcomes (e.g. a model or prototype of an envisioned solution and its verbal explanation) embody the negotiation and value trade-off processes between children during co-design activities.
- To deduce children's values, different co-design outcomes or modes (e.g. material artifacts and their verbal explanations) need to be interpreted in relation to each other and the context in which they were created.

9.3.2 Theoretical foundations

The GLID method builds on concepts from two theoretically grounded approaches: Multimodal semiotics and means-end theory. A basic understanding of the concepts borrowed from these approaches is necessary to apply GLID for analyzing co-design outcomes.

9.3.2.1 Multimodal semiotics

Multimodal semiotics is an approach that assumes that communication includes several different modes (such as writing, image, sound) that contribute to the meaning of a message (Kress, 2010). Each mode has different affordances: specific characteristics that make them suitable for communicating specific information (Jewitt, 2010). For example, while text is more suitable for narratives, images can be easier to communicate moods and emotions. Multimodality integrates all these modes in one holistic analysis. For the analysis of co-design outcomes, we use a division in general modes of communication, such as 'verbal' (the participants' explanations, either written or oral) and 'material' (artifacts, including their visual and tangible features) modes.

Multimodal semiotics furthermore distinguishes between the different functions that every communication fulfills. Three basic functions, called metafunctions, are identified that analyze:

- What or which reality is represented?
- Who is involved, how are social relationships constructed between actors in this reality?
- How is the communication structured as a coherent entity that makes sense?

The multimodal analysis into communicative modes and metafunctions aims to offer insights into how communication is structured, and how it presents a specific view on reality. Such "socially constructed knowledges of some aspect of reality" (Van Leeuwen, 2005: 94) are called discourse, in multimodal semiotic terminology. In every communication, reality is represented in a selective, socially constructed way. Specific aspects of reality are included and arranged in a particular way, and as such, each selection indirectly represents a set of socially shared values (Barker and Galasinski, 2001). Therefore, the multimodal analysis will play a central role in the GLID method as it is instrumental in making explicit how a specific view on reality is constructed in co-design outcomes.

9. 3. 2. 2 Multimodal Semiotics, Discourse and Values

In the GLID method, we will use multimodal semiotics to analyze the discourse embedded in the co-design outcomes. This analysis of discourse will lead us to an insight into the values that underpin the co-design participants' outcomes. In order to clarify our use of a multimodal, semiotic approach for the analysis of values in PD, we will complement it with a brief discussion of means-end theory. According to means-end theory, people choose a product because it contains certain attributes (the means) that are instrumental to achieve desired consequences or benefits, which, in turn, fulfill certain values (the ends) (Gutman, 1982; Reynolds and Gutman, 1988).

Means-end Theory and Multimodal Semiotics drill down to respectively discourse and values in a similar way (see Figure 46). While Means-end Theory describes how surface features are related to underlying values, Multimodal Semiotics describes how surface features combine into specific discourses. Values and discourse are not interchangeable, but most values are embedded implicitly in the way participants represent reality in a selective way. Through the analysis of discourse (i.e., analyzing the situations described in the co-design outcomes, and the way they change the current status quo), it becomes possible to access

MEANS-END THEORY	MULTIMODAL SEMIOTICS
Product features (cf. attributes)	Product features
↓	↓
Direct and indirect consequences or benefits	Communicative modes and metafunctions
↓	↓
Values	Discourse

Figure 46: Means-end theory and multimodal semiotics 'drill down' to respectively values and discourse in a similar way.

the social value systems embedded in it. Inspired by applications of means-end theory progressively 'drilling down' to an analysis of underlying values, GLID uses multimodality in a similar way to analyze co-design outcomes.

9.3.3 Applying the GLID analysis method

GLID relies on Means-end Theory and Multimodality, and consists of four, iteratively applied steps: (1) Grounding the analysis, (2) Listing design features, (3) Interpreting orientation and organization, and (4) Distilling discourse and values (see Figure 47).

9.3.3.1 Step 1: Grounding the analysis

What?

Inventorying the set of initial ideas that came up during the sessions. Tracing the evolution from initial ideas to final outcomes, and situating the final outcomes against the background of their origins.

Figure 47: The four broad stages of the GLID method for analyzing co-design outcomes.

Why?

Situating co-design outcomes in its origins can clarify why certain (design) decisions were made. Tracing the origins can help to contextualize the eventual outcome, especially when that outcome proves to be ambiguous in some respect.

Apart from grounding the analysis, it can be enlightening to see how the initial ideas have been transformed during the co-design process and how they have made it into the final outcomes. Tracing the evolution of the selected ideas can already give a first insight into the type of outcome that was targeted (Van Mechelen and Derboven, 2014).

How? Relevant questions

How did the co-design outcomes grow and transform into their final form? Which early, constituent ideas can be traced? Which ideas did not make it to the final outcomes?

9. 3. 3. 2 Step 2: Listing design features

What?

Listing design features in detail. Differentiating between different modes of communication (visual, material, etc.), and tracing which features are communicated in which modes.

Why?

Listing design features provides a basic description that can be used for further, more thorough analysis. This listing of features can also provide a first insight into which features are highlighted as the most salient features, and which features have been given less attention.

This stage is based on the first of the three metafunctions in multimodality: the presentational metafunction (the terminology is based on Lemke's (2002) view on metafunctions). The presentational metafunction is related to the concrete, functional layer of designed artifacts. It is a description of the 'state-of-affairs', detailing what aspect of reality is presented in the co-design outcome. It describes what is represented, and what activities potential users or stakeholders engage in. As such, both functional (actions that can be performed) and non-functional (visual, aesthetic) aspects of the co-design outcomes are described. In means-end terminology, this is a detailed overview of the directly perceivable attributes (material, visible product features) and their functional consequences (immediate tangible benefits: the purposes they serve and the interactions they allow).

Furthermore, combined with the first step (Grounding the Analysis), various design features can already be traced back to their origins. This additional background on the design features provides the basis for the analysis described below.

How? Relevant questions

What do the co-design outcomes consist of? Which features do they have? Which features stand out? Which actors and objects participate in the reality presented through the co-design outcomes? Which modes are present in the co-design outcomes? In which mode are the features communicated? What are their functions?

9. 3. 3. 3 Step 3: Interpreting orientation and organization

What?

In this stage, the analysis focuses on how the co-design outcomes are presented as a coherent whole, projecting a reality with specific social relationships between various actors.

Why?

This step is based on the two last metafunctions identified by multimodality: the orientational and organizational metafunctions.

Orientational

This analysis focuses on contextual social relations, and therefore specifies 'attitudes' towards the state-of-affairs in the co-design outcome mentioned above. Analyzing the features' orientation determines how actors, in the reality projected by the co-design outcome, are (implicitly or explicitly) involved in the interaction with the outcome. As such, the orientational metafunction focuses on social consequences. It evaluates and positions the situation (desirable or not, necessary or obligatory, etc.) and evaluates the relationships among participants and objects (in terms of power relations, influence, etc.).
The orientational layer is especially important for PD, as it specifies how specific social situations are evaluated, offering insight in the way in which specific values are embedded. In other words, this analysis focuses on shared meanings, attitudes and relations that hint towards specific values (Lemke, 2002).
Linking multimodality with means-end theory, the orientational meaning relates to psychosocial benefits. It is an analysis of how the co-design outcome intervenes in a specific situation, and which psychological or social consequences are linked to it. These consequences embody the meaningful, alternative futures envisioned by the PD participants.

Organizational

Analyzing the features organizationally shows how the co-design outcome as a whole is constructed as an artifact, a story or in another discursive form. Here, the focus is on how the initial co-design idea or challenge was 'translated' into a coherent outcome, integrating or contrasting different features and value orientations into a whole.
The interaction between the various modalities is important. As different modes can communicate different types of information, it is important to analyze how different modes work together in order to communicate a message (i.e., the cohesion between modes). Do

different modes confirm and reinforce each other, or contradict each other? Are the same features present across modes presented in a similar way ('transduced' (Kress, 2010) from one mode to another), or do different modes emphasize different features?

How? Relevant questions

Orientational

Which actors are involved in the use of the artifact, directly and indirectly? Which stakeholders are mentioned by the co-design team and which are not? What are the relationships among these actors, and how does the artifact mediate these relationships? What are the psycho-social benefits for the different actors?

Organizational

How was the initial co-design challenge or idea brought together into one co-design outcome? How does the outcome constitute a meaningful whole (application, tool, etc.)? How are specific messages confirmed and reinforced (highlighted) across modes? Does the analysis lead to contradictory interpretations across modes?

9. 3. 3. 4 Step 4: Distilling discourse and values

What?

Distilling the discourse based on the previous analytic stages. In this stage, the focus is which specific discourse is used to envision future practices and technologies, and which values this discourse represent.

Why?

In this stage, the previous stages culminate in a meta-analysis of how the future practices and situations evoked in the co-design outcomes are evaluated in terms of the PD participants' underlying and negotiated values. Guided by the trajectory from initial idea to eventual co-design outcome (Grounding stage), this stage sums up how the co-design outcome represents a specific aspect of reality (Listing stage), combining various modes of communication in a coherent way (Interpreting stage: organization). Together, these elements form the specific discourse (a 'socially constructed knowledge of some aspect of reality' (Van Leeuwen, 2005)) presented in the co-design outcome. The outcome therefore represents a specific selection and configuration of that reality: e.g., social relationships between actors are always constructed in a particular way (Interpreting stage: orientation).

As such, the meta-analysis builds on the previous analytic stages to show which specific discourse is used to envision future practices and technologies, and which values this discourse represent. This discourse is essentially a coherent synthesis of the analysis from the second and third stage. However, in this phase, the goal is to transcend the details of the specific situation described in the co-design outcome (e.g., specific functionalities - see Listing stage), and move towards the values that underpin and motivate these specific, contextual details. From this discourse, specific value orientations can be deduced.

How? Relevant questions
Which aspects of reality are included and excluded in the co-design outcomes? How are these aspects of reality evaluated? How does the artifact represent and influence this reality? With what purpose? How is it legitimated? Which set of values is communicated through this representation of reality?

9. 3. 4 Additional guidelines for using GLID

9. 3. 4. 1 Adopt a reflexive attitude

GLID is an interpretative approach aiming to analyze values embedded in co-design outcomes. In the different steps of the GLID method, step 3 and step 4 are the most interpretative ones. Since the process of interpretation is not value free, multiple and equally valid interpretations can co-exist. Therefore, it is important to be aware of the values that you bring to the co-design process, and to explicate how these values influenced your interpretation. This type of reflexivity is an important additional step during the analysis, but also when preparing co-design activities relying on CoDeT. A useful tool that can be used for this purpose is CHECk (Read et al., 2013; Van Mechelen et al., 2014b), developed to encourage reflexivity by means of two checklists with questions that should be used prior to any design activity. The overall goal of CHECk is to become more explicit about the values that drive your work, pushing you to the extremes of honesty.

9. 3. 4. 2 Extend the range of modes

Importantly, GLID is not a generic process and should be carefully adapted to the context in which it is applied. Whereas the tangible and textual modes are the most obvious ones, other modes (e.g. embodiment, process of negotiating meaning) can be included as well to arrive at an empathic understanding of children's ideas in relation to their values. To check the validity of the interpretation, the consistency or cohesion among these different modes should be analyzed. With GLID, the separate interpretations of different modes from step 2 are brought together in one interpretation in step 3. This allows for an analysis of similarities and differences between various modes.

9.4 Conclusion

The co-design toolkit, composed of CoDeT and GLID, offers a holistic approach to involve children as design partners at the early stages of technology design. With the CoDeT procedure, design researchers can prepare and conduct co-design activities with children, and anticipate on and mitigate challenging intragroup or co-design dynamics (cf. RQ1a). CoDeT is unique in how it structures sufficient work-group features and strengthens children's Design Thinking abilities in co-design activities. Relying on the GLID method, the outcomes of CoDeT co-design activities can be analyzed in a transparent and coherent way, and beyond the surface level of children's ideas (cf. RQ1b). Another characteristic of GLID is its thorough consideration of different modes (tangible, visual, textual, etc.) to arrive at children's negotiated values embedded in co-design outcomes.

A printed version of the toolkit can be obtained by sending an email to maarten.vanmechelen@soc.kuleuven.be. We call upon future researchers in the CCI community to apply and modify the CoDeT co-design procedure and GLID analysis method in a wide variety of design contexts, and to report on and discuss the use of the co-design toolkit.

Discussion and conclusions

The main research question addressed in this PhD research is how to design technology for children with children. Giving those who are destined to use a product or service a critical role in its design is a core tenet of the Participatory Design (PD) tradition. Although PD lacks a strict definition or a set of rules, its rich heritage offers a wide variety of methods, techniques and tools to scaffold participation in design practices. From this heritage, three core principles can be deduced that are still relevant today: sharing decision-making power with envisioned users and other relevant stakeholders, initiating a process of mutual learning between these stakeholders, and the co-construction of future technologies and practices which simultaneously entails action and reflection.

Often used in PD practices are generative techniques such as co-design to enable designers, future users and other stakeholders to externalize and embody their thoughts and ideas by the act of making artifacts. The physical artifacts resulting from such making or co-design activities typically represent envisioned technologies and practices, used to inform and inspire the further design process. With PD's core principles in mind, this PhD research focused on the use of co-design techniques with children in a school context, relying on two major assumptions: that children can contribute creatively to the design process, and that the socio-cultural context is an inherent part of the creative process.

Based on preliminary co-design experiences with children, we identified two challenges that were insufficiently addressed in literature. The first challenge relates to challenging group dynamics between children that hamper collaborative and creative endeavors in co-design activities. We noticed that when this problem was addressed at all in the field of Child Computer Interaction, researchers focused on remediating asymmetrical power relationships between adults and children, but neglected group dynamics between children themselves. This challenge resulted in the first research question (RQ1a) on how to address challenging intragroup dynamics, and structure cooperation more efficiently in co-design activities with children.

The second challenge we identified relates to the analysis of the outcomes of co-design activities with children. We noticed that robust methods to integrate visual and tangible dimensions of co-design artifacts, and their verbal explanation into a coherent analysis were missing.

The unilateral focus on the verbal explanation may imply that co-design techniques are regarded as a direct means to access children's perspectives, something Buckingham (2009) referred to as naive empericism. In addition, approaches that take a more interpretative stance to analyzing co-design outcomes often lack rigor and transparency. This challenge resulted in the second research question (RQ1b) on how to analyze co-design outcomes in a transparent and systematic way, looking at both the visual/tangible and verbal dimensions, and with the aim to identify children's underlying values.

To address these questions, we combined Research through Design (RtD) and Case Study research. RtD refers to using design processes as an inquiry methodology, which implies a constant reframing of the research questions based on newly gained knowledge. In our study, this knowledge emerged from different cases conducted over several years. The envisioned outcome of our RtD process was a co-design toolkit that would address both challenges. By addressing these challenges, we aimed to support researchers in designing the process of participation at the early stages of design and interpret the outcomes. Rather than developing a successful commercial product, the eventual goal was to more accurately define the problem space, inform potential solutions and estimate the impact on the lives and environments of children. In addition, we wanted the toolkit to empower children in two ways: (1) democratically, by raising awareness about how technology impacts on their lives and environments and enabling them to co-determine the direction and outcome of the design process, and (2) functionally, by teaching them the creative mechanisms of design thinking and how to collaborate productively towards a shared goal. An additional goal of our RtD process was to offer a reflective account on the different cases, the steps taken, and how these contributed to the development of the toolkit.

In total, four cases were conducted, each composed of one or more schools located in Flanders, Belgium. For each case, we focused on a target group of children aged 9 to 10, and the child-to-adult ratio was high (1 adult for 15 to 20 children). The first case study was the most exploratory one because the research questions were not fully formed at that point. In the second case study, we focused more in-depth on the problem of challenging group dynamics between children (RQ1a) and, retrospectively, on the problem of analyzing co-design outcomes (RQ1b). The second research question was also addressed in the third case study, and the first research question was revisited in the fourth case study. Each of these four individual cases had a separate embedded case, being the particular design challenge that was determined by the project. These design challenges should not be confused with the actual research questions that link the different cases together into a multiple-case embedded design.

The resulting co-design toolkit of this PhD research can be divided in two parts. The first part of the toolkit addresses the problem of challenging intragroup or co-design dynamics. The second part addresses the problem of analyzing co-design outcomes in a systematic way and with a concern for values. In what follows, we summarize our main findings for both research questions, and discuss limitations and areas for further research.

Scaffolding collaboration and Design Thinking

To address the problem of challenging intragroup or co-design dynamics, we developed tools to structure cooperation between children more efficiently. In order for design researchers to easily recognize dynamics that may hamper children's collaborative and creative efforts, we included a description of the most prevalent challenging dynamics that we encountered during our studies. In order to better understand and address these dynamics, we relied on Social Interdependence Theory (SIT) (Johnson and Johnson, 2005). According to this theory, that has been widely applied in Cooperative Learning approaches, five mediating principles are essential to set up a collaborative atmosphere and increase children's willingness to work together: positive interdependence, individual accountability, promotive interactions, adequate interpersonal and small-group skills, and group processing.

To scaffold children's creative abilities in co-design activities, we furthermore relied on a Design Thinking model developed by Thoring and Müller (2011). The model is characterized by, on the one hand, a constant alternation of projective thinking to generate ideas (divergence), and, on the other hand, reflective thinking on the impact of the projection which reduces the design space (convergence). Our rationale was that by introducing the creative mechanisms of Design Thinking in combination with SIT's mediating principles, children would be more able to reflect on their experiences and generate better ideas for future technologies and practices. In addition, we argued that these newly gained collaboration and design thinking skills would empower children to take ownership over their environment.

In the second case we first experimented with applying SIT's mediating principles and Thoring and Müller's (2011) Design Thinking model to co-design activities with children. This was an iterative process that, by the end of the fourth case, resulted in the CoDeT co-design procedure.

With the CoDeT co-design procedure we were able to reduce the amount of challenging intragroup or co-design dynamics, although we could not completely avoid them. We also noticed that managing these dynamics is often a matter of finding the right balance between

them, because they are interlinked. With CoDeT, we could prepare co-design activities with children more thoughtfully and, at the same time, anticipate on challenging group dynamics between children. Also, when these dynamics occurred, they were easier recognized and remediated into positive forces. For instance, to counter cases of Free Riding, we could gently point towards the child's role and responsibility in the team. Moreover, since children were encouraged to develop their interpersonal and small-group skills, they became increasingly capable of managing differing voices, with little adult facilitation. Overall, we noticed that teamwork is a gradual learning process and, in most cases, children need time to adopt a design mindset. Group processing proved to be an essential step in the CoDeT procedure to improve children's collaboration over time, because they were prompted to reflect on their experiences. Reflection resulted in a posteriori knowledge about teamwork and how they could change their behavior to improve collaboration and reach their shared goals.
Reflecting back on the envisioned impact as defined in the methodology section (see Chapter 3 pp. 68), the CoDeT co-design procedure supports PD's core principles in different ways. The first principle, having a say or democratic empowerment, is supported in that children define a problem statement based on an open-ended design challenge for which they envision a solution afterwards. In addition, relying on SIT's mediating principles, conditions are created to give each child equal opportunities to contribute to the design process. However, whether or not this results in feelings of ownership and critical awareness about the impact of technology on their lives and environment was not critically assessed throughout the case studies. As for the second principle, mutual learning or functional empowerment, relying on CoDeT researchers learn about children's ideas and how these relate to their values. In addition, children are guided through a design thinking process and learn to collaborate in a team. Co-realization, in turn, is supported in that researchers are offered tools to prepare and conduct co-design activities with children. Children are enabled to generate and visualize ideas together and to reflect on the impact of their projections by means of non-technical tools.

Despite these positive findings, there are some limitations to our study that will be subject to future work. The CoDeT co-design procedure was developed based on studies with children aged 9 to 10. A consequence of this narrow age range is that our findings may not apply to younger or older children. In addition, we focused on partnering with children at the early stages of technology design, also known as the fuzzy-front-end of design, to inform and inspire the exploration of open-ended design questions. In an authentic approach to PD, children should be involved in all stages of the design process (design time), and even beyond the design process, in order to implement and adapt the final design outcome in their own environment (design in use). Extending children's involvement to further strengthen their voice in the design process and working with different age ranges are topics for future research.

Another topic that should be investigated further is the importance of autonomy and structure in co-design activities with children. According to Self Determination Theory (Ryan and Deci, 2000), providing options and choices creates feelings of autonomy, increasing people's intrinsic motivation to achieve a certain goal. In addition to autonomy, experiencing mastery (competence) and feeling connected to others (relatedness) are innate psychological needs (Ryan and Deci, 2000; Zuckerman et al., 1978). In the CoDeT co-design procedure, children are granted autonomy in the way we implemented SIT's mediating principle outcome interdependence. For instance, teams are asked to define a design problem based on their interpretation of a (fictional) story that describes a puzzling situation with rich contextual details. Teams are also free in how they approach a particular task (e.g. prototyping), although the broad stages of divergence and convergence are predetermined.

The CoDeT procedure is in fact the result of a delicate balancing act between providing autonomy and setting boundaries to scaffold collaboration and Design Thinking. The amount of autonomy that is eventually granted to children largely depends on how the CoDeT procedure is implemented. When time is limited, design researchers can choose to predefine the design problem, roles and responsibilities, and rules of the game that apply to the co-design activities. In future work, we will investigate how these variations in autonomy influence children's intrinsic motivation, and, in turn, how this affects children's collaborative and creative endeavors. We will thereby distinguish between autonomy in determining goals and autonomy in how to arrive at these goals.

In addition to varying the amounts of autonomy, in future applications of the CoDeT procedure we also want to experiment with different types of roles for children. For now, we mainly used task-oriented roles (e.g. material guard, time keeper) to structure means interdependence, but more conceptual and goal-oriented roles can be added to increase children's interdependence and feelings of responsibility towards the team. A related topic of interest is how team composition impacts the co-design process. For now, we formed teams heterogeneously based on abilities, but it is unclear what the effect is when children choose teams themselves.

A final discussion relates to the role of design researchers in co-design activities with children. In schools, a broad variety of children can be found, which may lead to a more inclusive and more empathic understanding of children overall. However, not all children are equally motivated to participate in the design process, which may negatively influence collaboration and creativity. The question is to what extent design researchers should try to influence a fundamental disinterest of some children to being empowered in the design process. An additional challenge is how such disinterest can be distinguished from other causes, such as insecurity about one's competencies to make meaningful contributions. If insecurity rather than disinterest is the root cause for challenging intragroup or co-design dynamics, the question is how such misperceptions can be countered by positively reinforcing children.

Interpreting co-design outcomes

In the second part of the toolkit we tackled the problem of analyzing co-design outcomes in a transparent and systematic way, looking at both the visual/tangible and verbal dimensions and with the aim to better understand children's underlying values. This challenge was addressed in the second and third case, and resulted in the GLID method. To develop the method, we first looked into the multidimensional concept of value and how values can drive technology design. Eventually, we relied on three approaches that have concerned themselves with values: UX laddering based on Means-end Theory, the discourse surrounding Value Sensitive Design, and a values-led approach to PD. In addition, we borrowed from a social semiotic approach to multimodality to integrate the tangible and visual dimensions of co-design artifacts, and their verbal explanation into a coherent analysis.

The resulting GLID method is based on the idea that the act of making during co-design activities helps to raise awareness about one's own values and value trade-off processes. Values were defined as critical and relatively stable motivators of someone's attitudes and behaviors, that what someone considers truly important in life. Since co-design activities are a group process, these personal values are simultaneously negotiated with other participants, either implicitly or explicitly, which might in turn influence participants' personal value systems and reframe the design problem. This process of collective sensemaking, also referred to as collective reflection in action (Ehn, 1993) is at the heart of our approach. Co-design artifacts and their verbal explanations embody this negotiating and trade-off process. However, to arrive at a situated understanding of values, we argued that the artifact and its verbal explanation need to be interpreted in relation to each other and the context in which they were created. With GLID, we wanted to offer a stepwise procedure to engage with values, resulting in a profound and empathic understanding of what genuinely matters to children.

When applying the GLID method to analyze the co-design outcomes of the second case, we noticed that in none of the teams children explicitly discussed or negotiated their values. For 9- or 10-year old children, this may still be a bridge too far, because their abstract thinking skills are only beginning to develop, and values are per definition abstract concepts. However, co-design proved to be a useful technique to respond to children's cognitive development. The making activities stimulated ad hoc reflection and children did not have to think about complex and abstract issues without concrete reference materials. Also, since values are critical motivators for people's attitudes and behavior, the way in which children approached the design challenge and co-constructed a solution told us something about their values, be it implicitly. With GLID, we were able to deduce these values through a systematic process of interpretation.
The results of the analysis showed that some ideas and suggestions were neither realistic nor easily reconciled with educational goals. In addition, at first sight, some co-design teams proposed design ideas that seemed hard to combine into a holistic concept. However, by looking at the values embedded in the co-design outcomes, we could go beyond the attribute-level and whether or not these ideas were realistic or justifiable from an educational perspective. Moreover, design suggestions that seemed hard to reconcile, could be compared on a more abstract level. Whereas the amount of concrete ideas and suggestions was overwhelming, children's underlying values were few and less volatile. This allowed for easy comparisons, which brought potential value conflicts between teams and other stakeholders to the surface. This knowledge helped us to more accurately define the problem space and estimate the impact of envisioned solutions on children's lives and environment.

Applying GLID was not a linear deductive process, but an interpretative process that involved several iterations of going back and forth between the different steps. This included juxtaposing the different modes of the co-design outcomes (e.g., visual and tangible dimensions, verbal explanation), and analyzing these modes in relation to each other. In our case studies, we focused on the tangible and textual modes, but other modes can be included as well (e.g. the process of negotiating meaning, embodiment, and expressive resources used in co-design activities). When analyzing co-design outcomes with GLID, it is essential to pay attention to these different modes, and to analyze how these modes co-construct the co-design outcome, how they emphasize or downplay specific aspects of the design, and how the design as a whole mediates between different actors. This way, it becomes clear how the co-design outcomes embody specific value orientations as they are brought into a specific social reality. Since the process of interpretation is not value free either, multiple

and equally valid interpretations can co-exist. With GLID we were able to make this process more transparent by gradually constructing interpretations in a well-substantiated manner. Reflecting back on PD's core principles, integrating different modes of communication in a coherent and systematic analysis supports the principle having a say or democratic empowerment, because it results in a more holistic understanding of children's contributions. Also, the values identified with GLID can be traced back to their origins, that is, the artifacts' functionalities and their desired consequences, which further increases transparency because confirmation biases are easily recognized. The other principles, mutual learning or functional empowerment and co-realization, are only to a lesser extent supported with GLID. Whereas design researchers learn about children's ideas and viewpoints in relation to their underlying values, the interpretation of the co-design outcomes is detached from children. To complete the process of mutual learning, children should at least be debriefed about the results. This additional step was beyond the scope of this study, but in further research we will look for appropriate ways to initiate such discussions with children.
Another topic that should be further investigated is how children's ideas and values can drive the subsequent design stages. So far, we focused on the early, fuzzy stages of design, and used GLID to more accurately define the problem space. Since values and the technology under development mutually influence each other, children's values need to be reconsidered throughout the entire span of the design process. To avoid a mono-cultural fit, other stakeholders will need to be involved as well, which raises the question about who makes the design decisions in these subsequent stages. A particular challenge is to avoid design by committee in participatory decision-making processes, without making children's voices subordinate to that of adults. Design by committee is a disparaging term used for design projects that lack a unifying vision by having to compromise between the viewpoints of different stakeholders. This process of sharing decision-making power throughout the entire span of the design process will be further investigated.

Alongside these future research trajectories, we hope for a wide uptake of the CoDeT co-design procedure and the GLID method by the CCI community, in different types of design projects, and with varying child-to-adult ratios and age ranges to further refine the toolkit. We argue that the flexibility of both methods will allow for such variations. Discussions on the usefulness of both applications in a diversity of situations will help to critically examine and further refine the CoDeT procedure and GLID method.

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